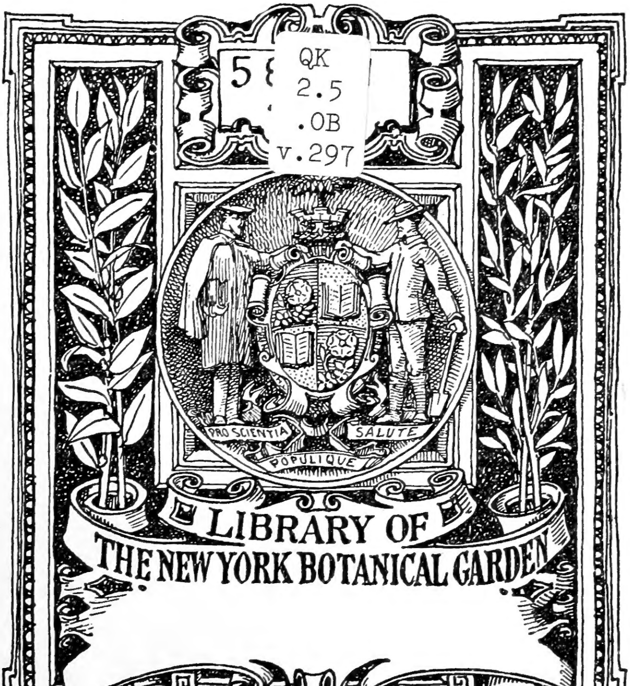
31 Mar 92


PRO SCIENTIA
SALUTE
POPULIQUE
LIBRARY OF
THE NEW YORK BOTANICAL GARDEN
Septemb 1897
R.W. Gibson Invt

Contents.

(No. 2)

# NATURE STUDY IN THE ELEMENTARY SCHOOLS.

1894

# NATURE STUDY IN THE ELEMENTARY SCHOOLS.

BY

CHARLES B. SCOTT,

ST. PAUL, MINN.

[*Reprint from Proceedings of American Institute of Instruction.*]

CONCORD, N. H.:
REPUBLICAN PRESS ASSOCIATION.
1894.

# NATURE STUDY IN THE ELEMENTARY SCHOOLS.

Amid such surroundings as these in which we meet, it seems unnecessary to make a plea for nature study. Every rock and crag, every hill and dell, invite and urge with irresistable power. In such a presence is it not almost presumptuous for me to speak of the mental broadening and the moral uplifting which come to the sympathetic, reverent, thinking student of nature as he surveys these mountains and valleys? Need I, a dweller of the plain, tell how much clearer is the vision, how much sharper the conception of these mountains of New Hampshire, which I get from a few hours personal face-to-face contact with them? Could any traveller tell me what I have seen? Can any book bring to me the pictures which these mountains have stamped on my mind? Will not what we see to-day help us better to understand and appreciate picture and traveller and book, telling of these and other scenes of nature? How much better will we, you and I, feel with the poet of nature as he voices the thoughts which speak but cannot be expressed? How much nearer are we drawn to the author of nature, through these his works?

But this is nature study, in nature's grandest labor-

atory, with nature's best instruments, the seeing eye, the hearing ear, the understanding heart. Why do you come here among these mountains for your gathering? Why do you, during half of your day, turn away from hall and platform, from teacher and book, and turn toward the open page of nature? To me this gathering of the devotees of the book, the upholders of authority, in this the very citadel and stronghold of nature, is prophetic; this division of the day between the study of man and his experiences, and the investigation of nature and her story is a harbinger of the better time when our boys and girls shall learn to use their own eyes and ears as well as calmly to appropriate what others have seen and heard, to do as well as to listen, to climb as well as to sit and absorb, to develop mental muscle and power as well as to be carried, to be raised from that which is sordid to that which is noble and inspiring in the works of man and the works of God, to be lifted from nature and through nature up to nature's God.

Shall we shut out from the education of the child that which so helps and develops, so broadens and elevates you and me? To the eye that sees, the swelling bud, the unfolding leaf, the opening flower, the germinating seed, tell a story no less wonderful than that which comes from these mountains, a story of care and purpose and plan. To the ear that hears, the song of the bird, the patter of the rain-drops, the singing of the tea-kettle, and bubbling of the brook, tell of work done and work to be done, of mutual dependence and mutual helpfulness. To the mind that thinks, to the heart that understands, the soil of the field, the sand

of the seashore, the very dust at our feet, tell of action and change.

The child will grasp the thought, will reach after the over-thought. To the child the book of nature is a book of revelation. Will you close it to him or will you open it wide before his eager eyes? The child has been given eyes to see with; while yet in the school of Dame Nature, before he came to you, he used his eyes with wonderful effect. They were the gateway to his world. Will you now limit his vision to the book, keep his eye fixed on the teacher, until the sight is dimmed for all else? The child came to you with expression in every movement, because every sense was alert and through every avenue he was receiving impressions. Will you limit his telling to that which he has not seen, to that which has been simply absorbed from book or teacher? The child entered your school full of curious "whys" and quaint "hows." Nature suggests them. That is nature's way of leading him to investigate and think for himself. You will not deaden this interest and stifle this curiosity, because it is n't in your book, because your scheme of education does not include thinking about that which is nearest to him, his environment. To this child of ours, whose training and education are entrusted to us, mother nature has given the sympathy and enthusiasm of the naturalist coupled with the spirit and imagination of the poet. Surely you will seize this opportunity which nature provides to keep the child turned toward higher and better things.

No, here, in such a place and before such a gathering, nature needs no advocate; she pleads for herself.

Nor need I plead for the child. Nature study and child study are but two phases of the same thing; the child is man nearest to nature, most natural; nature study and child study go hand in hand. Studying nature with the child will lead to the study of the child. Studying the child will, I am sure, lead to nature study

The child has a two-fold environment—nature and man. In his early life, the world of nature is his world. His earliest education is almost entirely in nature study and by nature's methods, an education of seeing and doing, of using his powers and developing them by using. Is there any reason why this should stop when he enters our school? Is there any more natural way, any better way, of developing his powers, than to follow the leading of nature, help and train him to see and do more and then to tell and think about what he has seen and done? Is there any knowledge which is more essential to him than a knowledge of his surroundings, of his world? Nor can he study anything which is purer and cleaner and more perfect than nature, which will appeal more strongly to the best in him, more effectually lead him up to the great thoughts which pervade all nature.

The education of the past has been too exclusively a study of one part of the child's environment—man and his experience, his language, his history, his methods of exact reasoning. Its method has been too much a process of absorbing knowledge from book or teacher with a resulting loss in the power of seeing and doing and telling and thinking.

The objects of nature study, this continuation in the school of the work of mother nature in childhood, are:

1. To develop the tastes of the child for the beautiful, to lead him to appreciate the best in nature, to think the great thoughts of nature, and to direct him to that which is above nature.

2. To develop the powers of the child, the powers of seeing, telling, and thinking, of observation, expression, and reasoning.

3. To give him a knowledge of all his environment, nature as well as man, of his relations to the present, as well as the experiences of the past.

Having touched on the objects or purposes of nature study it seems wise to consider some of the general principles which may help us in gaining these objects.

In the very beginning we cannot emphasize too strongly the fact that the centre and circumference of this work is the child. Its object is to interest, elevate, develop, and instruct the child. The college professor may teach botany, may plan everything with the sole idea of giving a clear, systematic, well-rounded knowledge of the plant or plant kingdom. The teacher in the elementary schools who thus plans her work will certainly fail. If she would have the best success, everything must be subordinated to the child, everything planned and conducted with reference to his nature and his needs. What he learns about nature is very secondary. What he gets from nature is all important. Success or failure in nature study, or in the method of education of which nature study is the simplest and best exemplification, depends primarily on our center, our point of view. If we approach it from the standpoint of the child, become as little children, we shall enter the kingdom. If we do not, we shall fail.

This has been most forcibly impressed upon me by my own experience. When, as a high school teacher, I first became interested in the work with children, I was fresh from the university laboratory, an enthusiastic student of morphology and anatomy, of form and structure, and with the idea that nature only yielded her secrets to the wielder of scissors and scalpel, to the manipulator of section cutter and microscope. That I could study nature, my own environment, in its naturul condition, with my own natural eyes, had not been suggested to me. When I became interested in getting the children at work studying insects, with which we happened to begin our nature study, I naturally assumed that they would study as I had studied. I had found the structure of the grasshopper intensely interesting. So the children even in lower grades were put to work studying, in considerable detail, the structure of the grasshopper. The grasshoppers carefully and humanely killed were placed on their desk and they were asked and helped to find out all about their structure, their body and head, their legs and wings and other appendages. But they, and particularly the younger pupils, were not much interested. They handled the dead creatures in a very gingerly way, and more so after they had been in alcohol some time. They studied the insect carefully and thoroughly and, still following the college method, compared the structure of the cricket with it. But, strange to say, most of the pupils were disgusted with grasshopper and cricket and nature study, and many teachers dreaded "the grasshopper hour."

The study of the butterfly was much more success-

ful. For a scientific study of the insect, to gain a knowledge of the insect structure and plan, the butterfly, with its peculiarly modified parts, was not nearly so good as the grasshopper. But the children were attracted by the beauty and the bright colors and cared little about the structure. To my mind, with a training which tended to make me consider even the butterfly as a wonderful structure, but only a structure, a subject for dissection and microscopic examination, this was disappointing and at first inexplicable. The children listened with interest to the story of the life history of the butterfly, of its development from egg to adult. When some milkweed caterpillars were brought in and they saw them feeding, the interest became greater. When a few fortunate ones saw the caterpillar transform to the chrysalis, and the chrysalis develop into the adult butterfly, they became wild with enthusiasm and scoured the country for caterpillars.

When some pupils, better naturalists than their teachers, brought living crickets into the school, teachers and pupils watched them with the greatest interest, and the pupil who discovered how the cricket chirped was a Columbus. They gathered about even the despised grasshopper and watched his eating and walking and jumping with an attention which they had never given to his structure. Then the structure became interesting and intelligible.

The experience with plants was very similar. The seed became much more interesting after the children had discovered the life in it, had seen it develop and had watched the formation of root, stem, and leaves, and the absorption of the food material. Then the

seed became wonderfully attractive and its structure intelligible. They had discovered its work and had learned what each part had to do.

The leaf, at first studied as a mere shape, became attractive to them and was understood, when they studied it as a thing of life, when, beginning with its beginning, they investigated the ways in which mother nature had protected it during its winter sleep, when they watched the opening buds and saw how carefully each little leaf was packed. The bud revealed to them a story of protection, of care, which pointed to a Protector, and showed that the leaves, thus wonderfully cared for, must have a great work to do. As they studied that work, and saw how work determined structure and influenced form, form had a meaning and structure became interesting.

The lesson came to me slowly; it had to overcome strong predilections for structure and classification, but it was the more deeply and indelibly impressed. The child, and not the plant or animal or stone, must be the centre. Nature must be approached from the child's standpoint. Material and methods must be adapted to the child's nature and needs.

If this is so, if we must follow the leadings of nature, we shall soon find that the first essential is to gain the interest of the child. His senses form the gateway to his world. To interest, his senses always respond, the gate always opens; with interest awakened, with senses alert, every power of the child responds, and there is scarcely a limit to what he can do. This I know from experience. The children show a wonderful power of expression and reasoning, when the impression has

been clear and deep, has come through their senses, alert and wide awake, because of their interest. Nature study will never succeed until and unless the child is interested. Interest is not the end, but a means to a much higher end. I would give as a second guiding principle: keep the child interested. If interest lags, something is wrong. Material or method is not adapted to your pupils. Change them.

A third guiding principle which, as I have said, has been most deeply impressed upon me by an experience full of mistakes, many of you, doubtless, educated with and through and by the child, have long recognized. In the elementary school, and I am firmly convinced, as a result of experiment, in the secondary school also, nature must be approached from the standpoint of life and action, of function and work. The world that appeals to the little child is the world of action and movement. Nature study for the younger children must be entirely a study of living nature—for the children of all grades must begin with life and action. Experience shows that during their first year or two in school children are much more interested in plants and animals than in stones. The children have become enthusiastic in watching the buds unfold and develop leaf and flower, or in observing from day to day (as thousands of our children did this spring) the development of bean and pea and morning glory, the formation of root and stem and leaf and flower, and finally of pod and seed, until the cycle of life is complete. Even the earthworm, from which the children would at first turn in disgust, became very interesting when they had been led to study its burrows and food, watch its

movements, investigate its means of locomotion and trace the circulation of blood in its body. After the study of life and function, structure had a meaning to them. They understood and were interested in it. Even the flower, whose beauty always attracts the child, no matter how approached, became more attractive, had a deeper meaning, when the child discovered that the flower and each part had a special work to do, and learned that even color, and odor and honey were aids in performing this work. Through the flower, that emblem of all that is beautiful and pure, I believe they cannot but gain a higher realization of their place in life, a purer and holier conception of the great mystery of the origin of life.

Even the stones tell the children a story of life or energy or action. The limestone, with which our country about St. Paul is covered, they approached through snail and snail-shell and clam, until the children themselves deciphered the story of the past, which its fossils told. The sandstone is a story, as well as a structure, a story of the action of water. The soil at their feet has told them how water and air have joined hands in making this earth fit for man's habitation. The crystalline rocks, limestone and granite, they understood after they had seen the formation of crystals of alum, and salt and blue vitriol. Then the crystals had a story.

Thus every plant and animal and stone becomes to them not merely a "what," something to sharpen their observing powers, and develop and clarify their powers of expression; the very stones at their feet ask why? and how?; bring into play every power of their mind.

Those of you who have seen the child thus in touch with nature, not merely with the framework and skeleton of nature, have been amazed, as I have been, with the power the children show to think and reason for themselves, and as you have seen the children look up from Madam How to Lady Why (as Kingsley expresses it), have been impressed as I have been, with the truth of the saying, that these things are hidden from the wise and prudent, but revealed unto babes.

From life and function, the main thought in the earliest years, the child insensibly passes to structure and later to comparison and classification. In placing classification first, as is so often done, the order of nature is completely reversed.

We have chosen our centre, the child. We have glanced at the roads, the senses, through which the child is connected with his world. We have felt of the threads so fine and yet so strong, attention, interest, concentration, through which the child and his world are to be kept in touch and the child developed; we have seen how he lives at first in a world of life, and function, and energy and action, whose borders gradually extend to include structure and classification. It seems scarcely necessary to add that in material as well as in method the child's world must be our world, and we must begin with that which is nearest to the child. You ask what to study. That which is most abundant, most common, most a part of the child's environment. Anywhere and everywhere the child is surrounded by the plant world, the germinating seed, the opening bud, the leaf and flower and fruit. My own experience with

teachers has convinced me that plant life furnishes the best material for beginning nature study. The most common weeds and garden plants are the best, the bean and pea and morning glory and corn, the plaintain and burdock and dandelion. These are a part of every child's environment, are abundant everywhere, even in the heart of the great cities; they are interesting, simple, and easily understood, and can be placed in the hands of each child, so that each child can see and tell and think for himself. Their whole life history can often be easily followed. I believe, too, that the teachers are more familiar with plants than with animals or minerals or physics or chemistry.

Need I say: It must be a plant study, not book study, the genuine personal individual investigation of plants by the pupils themselves. The teacher who, under the guise of nature study, merely reads to her pupils or merely has them read about the curious plants and ferocious animals of Europe, Asia, and Africa, and never turns their eyes to the dandelion at their feet, the birds and insects above them, should be shut up in an educational reform school until she amends her ways. The teacher who places before her pupils a book from which to absorb what they should see with their own eyes, who tells them what they should investigate and discover for themselves, violates every law of the educational decalogue.

After some work with plants, which can be most emphasized in the spring, some animal study can be taken up, particularly in the fall. In this, insects and birds will usually be found most abundant, attractive,

and easily studied. During late fall and winter, when living nature sleeps, rocks and soil, water and its forms, air and winds, and elementary physics may take the attention of the child. In all, that should be first selected which is most common, most a part of the child's every day life, which will best lead him to think about, and help him to understand, his surroundings. Later, as his world enlarges, what he has learned about his immediate environment will help him to understand that which is more distant, and become a basis for comparison and classification.

Nature study will not have the best success, unless it sets the child at work studying nature out-of-doors, under natural conditions, as well as in the school-room. It must be a means of bringing out-of-doors into the school and of carrying the school out of doors, of binding together all the child's environment. As the child studies in school that in which he has become so interested out of doors, as he goes to nature to investigate that which he has studied in school, all his environment becomes his school, as nature intended it should be. In this work nothing will be more profitable than occasional excursions, not picnics, but field lessons, more carefully planned and conducted than any lesson in school. Nothing, I believe, will draw teacher and pupils nearer together than to thus become fellow students of nature, fellow-workers in the investigation of truth, under conditions where all are teachers and all pupils. In the field the poorest pupil in school may be the best teacher.

The student must not merely observe; he must learn to express himself through language and drawing and

other mediums of expression. What is more natural than to have him tell, in words, or by drawing or painting or model, about what he has seen? Will he be more interested in expressing anything else? Is he not likely to do the best work in expression when he has had the strongest impression? We have found it so. The power of the pupils of expressing clearly and truthfully by language and drawing, has shown a very marked improvement. The pupils write and draw better, very much better, because they are interested and have something to tell. Nature study thus becomes a basis for much of the work in language and drawing. It forms, in the earlier years in school, the best possible foundation for geography. It is as closely connected with reading and literature. It becomes, not merely a connecting link between school and out-of-doors, a bond of union and sympathy between teacher and pupils, but also a means of unifying and correlating most of the work of the school, particularly in the earlier years. Nature is one center; the other is man and his experience, more and more important as the child gets older.

The child should first study nature with his own eyes, but he must not be limited to what he sees. He must learn what others have seen. He must look at nature through the eyes of the poet and other loving interpreters of her thoughts. Nature study thus becomes a means of better understanding and appreciation of the best in literature.

The study of nature misses its highest purpose, and the great purpose of all education, unless it leads the child from nature up to the Author of nature. Unless

the seen points the child to the unseen, from care and protection he looks up to a Protector, through function and purpose and plan he sees a Planner, nature has not revealed to teacher and pupils its greatest thought, its grandest lesson.

# An Outline of Nature Study and History and Literature

Compliments of

CHARLES B. SCOTT,

State Normal School,

Oswego, N. Y.

# AN OUTLINE

OF

# NATURE STUDY

AND

# HISTORY AND LITERATURE

AS AT PRESENT PURSUED
IN THE

## SCHOOL OF PRACTICE

OF THE

## Oswego State Normal and Training School.

---

OSWEGO, N. Y., JANUARY, 1896.

---

PRESS OF R. J. OLIPHANT, OSWEGO, N. Y.
1896.

Physical Laboratory of School of Practice.

# INTRODUCTION.

In arranging a course of study it is important to understand the true object of study and the relations that exist between the different subjects of study. Without this knowledge it is not possible to arrange the subjects in their proper order, nor to attain the highest results of study. The first question we have to answer is, What is the object of study? What higher or more rational aim can there be than that we may know God and obey Him? Such knowledge and conduct lead to the highest human attainments and happiness. Just in proportion as we understand God's modes of working, and live in harmony with them, will our lives be blessed—blessed in the amount of good we accomplish and in the avoidance of the ills that always follow disobedience to law.

But how are we to know God? Evidently by studying His works. And what are His works? They may all be arranged in two classes—material and immaterial objects. The material objects we are accustomed to arrange in three groups—animals, vegetables, and minerals. In studying the material objects we get ideas of form, size, relation—the elements of geometry and the arts; sound, color, weight, motion, and qualities generally—elements of physics, chemistry, and the arts; number—leading to arithmetic and algebra; place—leading to geography.

Human souls are immaterial objects of creation. This is sufficient for us to know in regard to this class of created objects. One of the most reliable and effective ways of studying human souls is in the study of history and literature. Here it is that we find recorded the thoughts, feelings, emotions, passions, actions, and motives of men. This is an important branch of psychological study, and one happily adapted to all grades of instruction. In these two great lines of study we gain ideas which we wish to express. The different modes of expression may be grouped under four heads:

1. Pantomime, which includes gesture and elocution.
2. Signs and symbols, as used in mathematics.

3. Art, including drawing, painting, moulding, sculpture, music, and architecture.

4. Oral and written language, including spelling, writing, reading, grammar, rhetoric, etc.

These expressive subjects may in turn become objects of study for the purpose of gaining greater facility in expression.

If this classification is correct, then we have three great groups of studies—the physical, the psychical, and the expressive sciences. The first two are the thought studies, and the last the language or expressive studies. That the thought studies should come first in order of time is a logical conclusion. It is true they cannot be separated, but the logical order must be observed, notwithstanding.

This arrangement of studies may be expressed in tabular form as follows:

## ARRANGEMENT OF STUDIES TABULATED.

MATERIAL OBJECTS OF STUDY.

| | | | | |
|---|---|---|---|---|
| **Plants.....** | The study of these material objects gives us ideas of | *Form, size, relation*—Elements of geometry and the arts. | Modes of expressing ideas gained in the study of objects, material and immaterial. | 1. *Pantomime*, including gesture and elocution. |
| **Animals...** | | *Color, sound, weight, motion and qualities generally*—Elements of physics, chemistry, and the arts. | | 2. *Signs and symbols*, as in mathematics. |
| | | *Number*—Leading to arithmetic and algebra. | | 3. *Art*, including drawing, painting, moulding, sculpture, music, and architecture. |
| **Minerals..** | | *Place*—Leading to geography. | | |
| IMMATERIAL OBJECTS. | | | | |
| **Human Souls** . | Psychology | History. Literature. | | 4. *Oral and written language*, including spelling, writing, reading, grammar and rhetoric. |

It is in accordance with this scheme that the course of study in our school of practice is arranged. At the very outset we begin with the nature studies, and story work—the starting-point in history and literature—and these two lines are carried on parallel to each other in daily lessons throughout the entire course. In these studies thoughts are elicited and ideas gained, and the children are encouraged to give expression to them in the most simple and natural ways—in pantomime, in words, by drawing, by moulding, by constructing, and by color. We are in no haste to teach them to read or write. We think it is better that they should get their ideas in other ways than from the printed page at this early age. With us the children enter upon this work from the kindergarten at from four to five years of age. Drawing and color work is more simple than writing, and interests the children more. At the proper time, and soon enough, they will learn to read and write.

At this stage of the child's progress no formal instruction is given in any of the expressive subjects; all such instruction tends to hinder freedom and readiness of expression. The duty of the teacher here is rather to encourage, guide, and direct, without giving any principles of the art of expression. In a separate issue the expressive branches are taken up and discussed in some detail as to time, order, and amount. This paper is designed to give only an outline of the work in nature study, and history and literature, out of which all the expressive subjects naturally grow.

We do not undertake to say, nor do we presume that the subjects taken up are in all cases the best that might be selected, nor that the order of arrangement is in all cases the best possible. All that we can say is, that at the present time the scheme presented is the one we are following. We have no expectation that it will be the same another year; in fact, our plan is to change from time to time. We shall come very far short of our privilege and duty if we do not continue to grow in this work, and all growth involves change. In the story work especially we expect to change the stories from year to year. The same stories will not be often repeated. Fresh material will be continually brought in. In the nature work, too, as conditions change the material used and the order will change. In these studies, as in all school work, frequent repetition tends to destroy all life and interest.

These outlines are not designed to give any detailed directions as to method of presentation. Only the matter and order are indicated. The method is discussed in the method classes before the pupil-teachers go to the school of practice.

The outline of the nature study has been prepared by Mr. C. B. Scott, who is in charge of this work. The outline in history and literature was prepared by Miss A. L. Harwood, who has the supervision of the same.

E. A. SHELDON, *Principal.*

# Nature Study.

## INTRODUCTION.

The following course of instruction in nature study, the result of several years of thought, experience, and experiment, has been arranged for the practice school connected with the Oswego Normal School.

The work outlined for the first four years is based entirely upon experience, and has been done, most of it, again and again. The work planned for the second cycle, beginning with the fifth year, has not all been done, as the pupils have not been prepared for it. Most of it will be done during the present school year—1895–96.

No work in astronomy has been included in the course. The fundamental facts in astronomy, which can be learned from observation by children, should be and are included in the study of geography.

## WHAT IS NATURE STUDY?

It seems wise to define at the outset our terms, and to state what is meant by nature study, and also to summarize the special objects or aims of the work.

By nature study is meant investigation by each pupil of the plants, animals, minerals, and physical phenomena which constitute his immediate physical environment.

Defined in detail, nature study is:

NATURE — STUDIED — IN ITS RELATIONS;
BY THE CHILD — FROM THE CHILD'S STANDPOINT;
BY THE TEACHER — WITH THE CHILD:
AS A MEANS OF DEVELOPING THE CHILD'S HIGHER NATURE;
AS AN AID IN OTHER SCHOOL WORK;
AS A PREPARATION FOR PRACTICAL LIFE.

### I. NATURE.

Not merely books or pictures.

### II. STUDIED.

Not merely talked about or read about; not merely glanced at, but carefully, patiently *studied;* personally investigated by every pupil.

### III. IN ITS RELATIONS.

Not as an isolated thing, but in all its relations:

1. *To the whole of which it is a part, and to the other parts of that whole.* The flower or leaf is not merely a flower or leaf, but is related to the whole plant and to every part of the plant. This brings out function, or use, and plan.

2. *To natural environment.* The plant or animal is related to water, and soil, and food, and air. This brings out life and function, and adaptation of structure to function or work, and impresses mutual dependence and coöperation.

3. *To past and future.* The study of plant and animal is very incomplete until we investigate its life history. The raindrop is but one stage in a vast series of changes or transformations. The fragment of rock or of soil is most wonderful and instructive when considered as a history of the past or a prophecy of the future.

4. *To other individuals, similar and dissimilar,* leading to comparison and classification.

5. *To other phenomena,* bringing out relations of cause and effect, and leading to general principles and laws. These relations are prominent in physics and chemistry.

6. *To man, ministering to his spiritual, ethical, esthetic, and material nature and needs.* Nature must be studied in its relations to man's higher nature, leading to the best in literature and art, and in its utilitarian or practical relations.

7. *To the Creator.* Nature reveals a Protector and Planner, and points to a purpose and first cause. Nature study misses its highest object and greatest value unless it leads to that which is above nature.

8. *To the school and to school work.* As a means of interesting and stimulating children; as a basis for expressive studies—writing, reading, drawing, modeling, painting, arithmetic; as a preparation for and aid in geography and literature.

### IV. By the Child.

Not merely by the teacher, or by the bright or interested children, but *by each child individually.*

### V. From the Child's Standpoint.

Not from the point of view of the mature mind, but as seen by the child, through the child's eyes, emphasizing life and action, habit and function, life history, leading later to structure and classification.

### VI. By the Teacher.

Not merely by the children. The teacher must study nature—not merely books—if she would lead the child to do the same.

### VII. With the Child.

Teachers and children fellow-investigators of truth.

### VIII. As a Means of Developing the Child's Higher Nature,

Spiritual, ethical, esthetic.

IX. As an Aid in other School Work,

Writing, drawing, reading, literature, geography, arithmetic.

X. As a Preparation for Practical Life.

Helping the child to appreciate, understand, and control his physical environment, his knowledge and mastery of which must largely determine his success or failure in life.

## WHY STUDY NATURE?

The objects of the work, as indeed of all education, are:

1. To interest the child in his surroundings, and arouse a sympathy and love for nature.

2. To cultivate his higher nature—spiritual, ethical, esthetic—and to lead him to recognize God as the author of all things.

3. To develop his powers of observation, expression, and thought.

4. To form right habits.

5. To give him a knowledge of his physical environment.

## THE COURSE OF STUDY.

In arranging the work for the different years, and in selecting the material and topics for study, we plan:

1. To arrange the work in two cycles, the first extending through years one to four inclusive, the second through years five to nine inclusive.

2. To study each topic in its relations, and not as an isolated thing.

3. To adapt the work to the nature and needs of the children at different ages—*always the first essential.*

4. To adapt the work to the teacher, selecting that with which the average educated teacher is believed to be most familiar.

5. To relate and adapt the work to other school work as much as possible, that it may aid and correlate with other studies.

6. To adapt the work to the season.

7. To adapt to the conditions and surroundings of the school, selecting the material and topics which can be studied in almost any school.

8. To so select material and arrange the work that the course can be abridged, or otherwise adapted to local conditions in other schools, without destroying the logical order or sequence.

## ARRANGING THE WORK IN TWO CYCLES.

The work (more especially that with plants and animals) is arranged in two cycles. In the first cycle, covering the first four years, an attempt is made to study all parts of the plant—root, stem, buds, leaves, flowers, and fruit—their growth, function, and general structure, and to get some ideas of one or two examples of the common types of animals—their life

and habits, life history, general structure, and a little of their classification; also to investigate the common "earth materials," "earth forces," and earth-making processes. During the second cycle the same ground, in the plant and animal study, is gone over more thoroughly, studying more examples, bringing in some new types, such as radiates among the animals, and the flowerless plants, and giving more attention to structure and classification. In the physical sciences the work of the second cycle is more thorough or intensive than during the first four years.

## STUDYING NATURE IN ITS RELATIONS.

The work has been so planned that everything shall from the first be considered in its relations. In watching, during the first three years, the development of plants from the seed to the formation of the seed (the first year, of one plant; the second year, of two somewhat similar plants; the third year, of two unlike plants), the pupils will learn to think of the plant and of every part of the plant in its relations to the whole plant, to other organs, to its surroundings, to other plants, to man and to God. The observation of trees throughout the year serves the same purpose. Great emphasis is also placed on the relations of the animal to its environment, leading to the study of its life and habits and of the function of its parts; to the past and future—its life history; to other animals, or comparison and classification; to man. The minerals and physical phenomena are also studied in their relations and applications. This study of relations should broaden the ideas and conceptions of the pupils.

## ADAPTING THE WORK TO THE CHILDREN.

The life sciences, plants and animals, are emphasized in the earlier years of the course, because it is believed that the study of life and of living nature is better fitted to develop the higher nature of the child, the spiritual and esthetic, and to cultivate his sympathies. Plants and animals also appeal more directly to the senses, while the study of physical phenomena and forces requires better developed reasoning powers. The latter are, therefore, more prominent in the later years of the course.

The physiological and dynamical side of nature is studied in the earlier years; the morphological and structural side, incidental with the younger children, is more and more emphasized in the intermediate and upper grades, leading to comparison and classification. At first, life, habits, function, development, growth, and life history, the processes by which our environment is being, has been, and will be changed, are made more prominent; later, structure, or adaptation to function and work, and classification.

In the earlier years the more interesting, simple, and obvious phases of nature are studied, but nearly every subject is studied during two successive years. During the later years fewer subjects are taken up, but they are studied more thoroughly. In the earlier years the work is extensive; in the later years, intensive.

While in nature study, as in all other school work, the child is everywhere and in everything the center, there are two subordinate centers, like the two foci of an ellipse—the child in his relations to his physical environment, or nature, and the child in his relation to his intellectual environment, or man. Above all, and including all, are the child's relations to his spiritual environment, or God. In the earlier years nature is the main center, because the physical environment appeals more directly to the senses; emphasis should then be placed upon personal observation of nature. In the later years of the course man is made more prominent. This leads to the study of the discoveries man has made; the way in which he has grouped natural objects, leading to systematic science; the use man has made and is making of nature, bringing out the practical side—mining, manufacturing, and commerce—and correlating the work with geography and history; the thoughts which nature has inspired in other minds, leading to literature and art.

In the earlier years of the course the thoughts of protection and care, of mutual dependence and mutual helpfulness, are emphasized, particularly in the plant and animal study. These phases of life appeal most strongly to young children. In the later years the attention of the pupils is drawn more to the order and system and law shown in nature. An effort is made to have the older pupils look at nature broadly, to think of the purpose and plan manifested in the world around them. It is believed that such thoughts, coming direct from nature herself, will, on the one hand, lift the pupils toward the Protector and Orderer and Planner, and, on the other hand, help them to better appreciate the relations of mutual dependence and mutual helpfulness between them and their fellows, and, indeed, between all phases of nature.

## ADAPTING TO THE TEACHER.

It is believed that better work will be done by the teachers if, so far as is possible, only one or two phases of nature are studied at the same time. For this reason, and for others, in all grades plant study predominates in the spring, animal study in the fall, minerals and the physical sciences during the winter. Some phases of plant study, such as seeds and fruits, must be and are studied in the fall, and some phases of animal study, such as birds, in the spring.

As teachers in general are more familiar with plants than with animals, and as it is easier for them to get, preserve, and study plants, special emphasis has been placed on the plant study. Comparatively little attention (none until the fifth year) has been given to flowerless plants, as the average teacher knows little about them. Provision is made for the study of these during years five to eight inclusive.

## RELATING TO OTHER SCHOOL WORK.

The work in minerals and in physics during the first four years has been planned almost entirely with reference to its value as a preparation for and aid in the study of geography. Minerals are considered as "earth

materials," and only the most common "earth materials," such as limestone, quartz, and sandstone, and the granitic rocks, are studied. Physics is a study of "earth forces," and only water, air, and heat are studied during the first four years. As an aid in geography, much attention is given to soil-making and to the work of water in producing the inequalities of the earth's surface.

The facts, ideas, and principles gained by observation in nature study not merely prepare for geography, but are expressed by the pupils, and become a basis for language (oral and written), drawing, painting, modeling, and other forms of expression, and are used as much as possible in the arithmetic work.

In all grades the observation of nature prepares for and leads to the best literature of nature. Nature study thus becomes one of the centers, the other being history and literature (or "man study"), about which the work of the school is grouped.

## ADAPTING TO THE SEASON.

The study of life, plant and animal, is emphasized during the seasons, fall and spring, when life most attracts attention. During the late fall and the winter months inorganic or lifeless nature, its materials and forces, are studied.

An effort has been made to adapt the topics for each month to the season. Such topics as "soil-making," "work of water," "dissemination of seeds," are suggested during two or three months in succession; they can always be studied during one of these months, whatever the character of the season.

## SELECTING MATERIAL AND TOPICS.

In selecting or suggesting material or topics for study during the different years, the following ideas have governed:

Those plants and animals have been selected for the earlier years which are most common, most interesting and attractive, most easily preserved and studied alive, and whose life and life history can be most readily observed under natural conditions. Later, more attention is given to those which are typical or representative in structure, such as the starfish.

Those rocks and minerals have been selected for study during the earlier years which are the most common "earth materials" (such as limestone, sandstone, granite), and those processes emphasized which best illustrate "earth-making" (such as soil-making and the work of water). Later, minerals of special economic importance, such as coal and iron, are studied.

In the physical sciences the same idea has been followed. Physical forces are studied first in their relation to our earth as "earth forces." Water, air, winds, and heat are considered during the first four years. During the later years those topics are considered first which seem most fundamental, such as gravitation and the pressure of liquids. More diffi-

cult and complex topics are left until the later years. Physical sciences are strongly emphasized during the last two or three years, on account of their great practical value, in accordance with the idea, already advanced, that the work of the later years of the course should be more and more grouped about man as a center. The topics requiring better developed reasoning powers are left until these last years.

The "field lesson" topics are those which must be studied out of doors, if their study is to be of much value.

## ABRIDGING AND ADAPTING THE COURSE.

In the practice school nature study and its related work in expression and literature is allotted (throughout the year) thirty minutes daily during years one to three, one hour daily during years four to six, and one hour three times a week during years seven to nine. Experienced teachers could do in less time the work outlined. In the school of practice this work is all done by pupil-teachers.

To aid those who may wish to abridge or select from the course, the more important topics are printed in ordinary type, while those which seem least important are printed in italics. In general, the topics are arranged, in the work for each month, in the order of their importance, considering the general plan of work; usually the easiest or simplest topics are placed first.

Plant study will be found the easiest in beginning work. Plants are abundant and easily obtained, are easily preserved, and simple and readily studied by each pupil, and are attractive to all; usually teachers know something about plants, much more than about animals or minerals. Plant study also correlates more readily with literature. Animals and minerals are at first much more difficult than plants.

It seems wise, also, at first to leave the teachers considerable latitude. In this work, particularly, teachers will succeed very much better with topics in which they themselves are interested.

When first taking up nature study in other schools, it is urged that during the first year of nature study the work be largely confined to plants during fall and spring, and to elementary physics, water, air and heat, during the winter months. During the second year more can be done with animals and minerals.

In beginning systematic science work it is impossible, of course, to follow at first a graded course of study. The work outlined for the upper grades requires, and is based upon, the work in the lower grades. It is recommended that, in beginning systematic science work, during the first year all pupils in grades two to four follow the work outlined for the second year, and all pupils in grades above the fourth follow the work outlined for the third year, adding, in the upper grades, such topics as may seem wise. By doing this, good foundations will be laid for definite work in the future in all grades.

## FIRST CYCLE—PLANT STUDY, ANIMAL STUDY, MINERAL STUDY, PHYSICS.

### FIRST YEAR.

| MONTH. | PLANT STUDY. | ANIMAL STUDY. | MINERAL STUDY. | PHYSICS. | FIELD LESSONS. |
|---|---|---|---|---|---|
| SEPTEMBER. | One or two plants as wholes. Formation of seeds. | Caterpillars and butterflies. | | | *Homes and food of insects.* |
| OCTOBER. | Dissemination of seeds. *Falling and colors of leaves.* | Snails. | | | Dissemination of seeds. *Falling of leaves.* |
| NOVEMBER. | Fruits. *Preparation of buds for winter.* | Fish or bird. | | | |
| DECEMBER. | Evergreens. | | | | |
| JANUARY. | | Shelter and protection of animals and of men. | | | |
| FEBRUARY. | | | | Water; its forms and work. | |
| MARCH. | Development of buds. | | | Water (continued). | |
| APRIL. | Buds. Life history of bean or pea. Unfolding of leaves. *Germination.* | Birds; their return. | | | |
| MAY. | Life history of bean or pea. Buds. Leaves. | Birds; their habits, mating, songs (of two or three). | | | Buds and leaves. *Birds and their homes.* |
| JUNE. | Life history of bean or pea. One or two plants as wholes. | *Birds (continued).* | | | *Homes of plants.* |
| GENERAL. | One tree observed throughout year. *Flowering plants in school.* | | | | |

NOTE.—The more important topics are printed in ordinary type; those less important, or supplementary, in italics.

## SECOND YEAR.

| Month. | Plant Study. | Animal Study. | Mineral Study. | Physics. | Field Lessons. |
|---|---|---|---|---|---|
| September. | Two whole plants (one a composite). | Caterpillars and butterflies. Crickets or grasshoppers. | | | Insects or spiders; homes and habits. |
| October. | Dissemination of seeds. Falling and colors of leaves. | Spiders. Snails (review). *Galls and leaf-miners.* | Formation of soil. | | Seeds. Fruits. Falling leaves. Soil-making. |
| November. | Fruits and grains. *Preparation of buds for winter.* | Snail and clam shells. Domestic mammals. *Turtle or fish.* | Formation of soil. *Fossils and limestone.* | | Formation of soil. |
| December. | Evergreens. | | Fossils and limestone. | | |
| January. | | | Quartz, sand and sandstone. | | |
| February. | | | | Water; its forms and work (review). Air; its presence and uses. | |
| March. | Development of buds. | Birds; their return. | | Air and winds. | |
| April. | Buds. Life history of bean and pea. *Uses and parts of leaves. Germination.* | Birds; their return. | | | |
| May. | Life history of bean and pea. Buds. Leaves. | Birds; habits (of two or three) and a little structure. Development of tadpoles. | | | Birds and leaves. *Birds and their homes.* |
| June. | Life history of bean and pea. Flowers. | Birds; habits and a little classification. | | | *Birds and their homes. Homes of plants.* |
| General. | Two trees observed throughout year. *Potted plants in schoolroom.* | | | | |

## THIRD YEAR.

| Month. | Plant Study. | Animal Study. | Mineral Study. | Physics. | Field Lessons. |
|---|---|---|---|---|---|
| September. | | Spiders. Galls and leaf-miners. Ants, bees, beetles, or flies and their larvæ. *Caterpillars and butterflies.* | | | Galls and leaf-miners. *Aquatic animals.* |
| October. | Flowers. *Two whole plants. Seed-cases and fruits.* | Crayfish. *Galls and leaf-miners. Spiders.* | Soil-making. Formation of valleys. *Collection of rocks and fossils.* | | Fall flowers. Soil-making. *Collection of rocks.* |
| November. | Grains and vegetables. Preparation of plants for winter. | Fish, turtle or frog. | Soil-making. Formation of valleys. | | Soil-making. Formation of valleys. |
| December. | Evergreens. | Corals, leading to fossils and limestone. | Limestone and fossils. | | |
| January. | | | Quartz, sand and sandstone (review). Feldspar, hornblende, mica. Granite. | | |
| February. | | | | Heat; its sources and its effects on solids, liquids and gases. | |
| March. | Development of buds. | | Soil-making. Formation of valleys. | Heat (continued). | Soil-making. |
| April. | Life history of two unlike plants. Buds. Germination. | | Soil-making. Formation of valleys. | | Soil-making. Work of water. |
| May. | Life history of two unlike plants (cont'd). Leaves; their forms and structure. Tree flowers. | *Birds; habits, development, structure, and a little classification.* | Soil-making. Formation of valleys. | | Soil-making. Work of water. |
| June. | Life history of two unlike plants (compl'd). *Flowers; their parts and plan.* | Birds (continued). | | | Trees and tree flowers. *Birds. Flowers.* |
| General. | Two unlike trees compared throughout the year, with careful notes and draw'gs. | | | | |

## FOURTH YEAR.

| Month. | Plant Study. | Animal Study. | Mineral Study. | Physics. | Field Lessons. |
|---|---|---|---|---|---|
| September. | One or two whole plants. *Fall flowers.* | Insects not studied before (such as dragon-fly). Classification of insects. | | | Roots and stems. *Earth-worms. Aquatic animals.* |
| October. | Roots and stems; their forms and structure. *One whole plant.* | Crayfish; structure and plan. Classification of arthropods. Earthworm; habits, structure. Classification of articulates. | *Soil-making. Work of water. Collecting rocks and fossils.* | | Collecting rocks and fossils. *Soil-making. Work of water.* |
| November. | | Mammals and other vertebrates. Classification of vertebrates. Starfish and corals. Classification of radiates. | *Soil-making. Work of water. Collecting rocks and fossils.* | | Collecting rocks and fossils. *Soil-making. Work of water.* |
| December. | | Classification of animals. | Limestone and fossils (review). Sandstone and stratified rocks. | | |
| January. | | | Granitic rocks; formation, properties, transportation (by glaciers) and uses. | | |
| February. | | | | Heat; production, absorption, radiation, conduction and effects. | |
| March. | Careful observation, with notes, of two or three trees. | | | Heat (continued). | |
| April. | Observation of trees (cont.) Leaves; their function, form and structure. | | Soil-making. Work of water. | Heat (continued). | Leaves. Soil-making. Work of water. |
| May. | Observation of trees (cont.) Leaves (cont.) | Birds and their classification. Frog's eggs and frogs. | Soil-making. Work of water. | | Leaves. Soil-making. Work of water. |
| June. | Observation of trees (cont.) One or two whole plants. *Roots and stems; their forms and structure.* | *Review of classification of animals.* | | | *Visit a collection of birds or other animals.* |
| General. | *Classification of trees. Recognition of poisonous plants.* | | | | |

Close of First Cycle.

## SECOND CYCLE—Plant Study, Animal Study, Minerals and Geology, Physics and Chemistry.

### FIFTH YEAR.

| Month. | Plant Study. | Animal Study. | Minerals and Geology. | Physics and Chemistry. | Field Lessons. |
|---|---|---|---|---|---|
| September. | Ferns. | | | | |
| October. | *Falling and colors of leaves.* | Articulates, including jointed limbed animals (arthropods) and worms (vermes); their life history (development from the egg), habits, relation to man, structure and classification. | | | Collection of minerals. *Falling and colors of leaves.* |
| November. | | | Common minerals. | | Collection of minerals. |
| December. | | | Common minerals. | | |
| January. | | | | Gravitation. *Properties of matter.* | |
| February. | | | | Pressure of liquids. Specific gravity. | Study city water-works. |
| March. | Trees. *Roots and stems.* | | | Pressure of gases. | Trees. |
| April. | Roots, stems and leaves. Trees. *Horse-tails (Equiseta).* | | | | Trees. |
| May. | Roots, stems and leaves. Trees. *Horse-tails (Equiseta).* | | | | Leaves. Trees. |
| June. | Trees. *Roots, stems and leaves.* | | | | Leaves. Trees. |

# SIXTH YEAR.

| Month. | Plant Study. | Animal Study. | Minerals and Geology. | Physics and Chemistry. | Field Lessons. |
|---|---|---|---|---|---|
| September. | Ferns (review). Flowers and fertilization. *Family characteristics of flowering plants.* | | | | Flowerless plants. |
| October. | Family characteristics. *Dissemination of seeds. Fertilization of flowers. Preparation for winter.* | Mollusks; life history, habits, relation to environment, relation to man, structure and comparison, classification and related forms. Radiates (corals, starfish and sea-urchins); occurrence, habits, structure and classification. | Sculpturing of earth's surface by water and air. | | Dissemination of seeds. Work of water. |
| November. | Dissemination of seeds. Preparation of plants for winter. | | Work of water, air and ice. | | Dissemination of seeds. Work of air, frost, ice. |
| December. | | | Coal (intensive study); occurrence, formation, properties, varieties, mining, transportation, uses. | | |
| January. | | | | Gravitation (review). Capillarity and osmosis. *Properties of matter.* | |
| February. | | | | Mechanics; levers, pulleys, wheel and axle, inclined planes. | |
| March. | *Buds.* | | *Work of water, air, frost and ice in sculpturing the earth's surface. Erosion, transportation and deposit by rain, streams and waves.* | Mechanics (continued). | Study machinery. *Work of frost. Soil making.* |
| April. | Buds. | Birds; life history, relation to environment (habits, food, movements), relation to man, structure and comparison, classification and related forms. | | | *Work of water and air. Soil-making.* |
| May. | Buds. Tree flowers. Flowers. Horse-tails (review). *Family characteristics.* | | | | Flowerless plants. *Work of water and air.* |
| June. | Family characteristics of flowering plants. *Flowers and fertilization.* | | | | Flowerless plants. |

## SEVENTH YEAR.

| Month. | Plant Study. | Animal Study. | Minerals and Geology. | Physics and Chemistry. | Field Lessons. |
|---|---|---|---|---|---|
| September. | Mosses. Family characteristics and classification of flowering plants. | Vertebrates. Fishes, reptiles and mammals; life history, life and habits, relation to man, structure and comparison, classification and related forms. Classification of animals. | | | |
| October. | | | | | |
| November. | | | Iron (intensive study); occurrence, formation, properties, varieties, mining, transportation, manufacture, uses. | | |
| December. | | | | | |
| January. | | | | Magnetism. | |
| February. | | | | Sound and light *or Elements of Chemistry.* | |
| March. | | | | Sound and light (continued) *or Elements of Chemistry (continued).* | |
| April. | Germination. Development and function of root, stem, leaf and flower. | Frogs; life history, habits and structure. | | | |
| May. | Germination (cont.) Family characteristics. Classification. Liverworts. | Birds; habits, structure and classification. | | | |
| June. | Family characteristics. Classification. | Classification of animals. | | | |
| General. | *Two or three trees carefully observed throughout the year.* | | | | |

## EIGHTH YEAR.

| Month. | Plant Study. | Animal Study. | Minerals and Geology. | Physics and Chemistry. | Field Lessons. |
|---|---|---|---|---|---|
| September. October. November. | Intensive study of several plants, emphasizing morphology (forms), structure and classification. *Flowerless plants.* | Note.—No animal study is planned for the eighth year. If preferred, some one division of animals, such as insects, birds or mammals, can be studied, as outlined for the ninth year. | Note.—No mineral study is planned for the eighth and ninth years, as it is believed better to give all the time possible to physics and chemistry. A study of local geology and fossils will be very profitable where teachers are interested. | Chemistry. | |
| December. | | | | Chemistry (continued). | |
| January. | | | | Chemistry (continued). | |
| February. | | | | Magnetism and electricity. | |
| March. | | | | Magnetism and electricity (continued). | |
| April. May. June. | A study of the physiology (function) and morphology (modifications in form) of roots, stems, leaves and flowers. *Flowerless plants.* | | | Magnetism and electricity (continued). | |

## NINTH YEAR.

| Month. | Plant Study. | Animal Study. | Minerals and Geology. | Physics and Chemistry. | Field Lessons. |
|---|---|---|---|---|---|
| September. | | | Note.—A study of local physical geography and geology will be very profitable, if teachers are interested. | | |
| October. | *Economic botany. Enemies of plants and their treatment. Practical uses of plants and of plant products. Intensive study of wheat, corn, cotton, etc.* | Insects; structure, classification, relation to man (beneficial or injurious). Collection and classification of insects. Classification of invertebrates (review). | | | |
| November. | | | | Chemistry, or careful study of one subject in physics. | |
| December. | | | | Chemistry or physics (continued). | |
| January. | | | | Chemistry or physics (continued). | |
| February. | | | | Chemistry or physics (continued). | |
| March. | | | | Chemistry or physics (continued). | |
| April. | *Food of plants. Plant physiology. Agricultural botany.* | Birds or mammals. | | | |
| May. | *Food of plants (continued).* | Birds or mammals (continued). | | | |
| June. | *Food of plants. Plant physiology (continued).* | Birds or mammals (continued). Classification of vertebrates (review). | | | |

Note.—Select either the plant or animal work outlined for this year; it is impossible to do both.

# Plant Study.

## ORDER OF STUDY.

In general, the order of study is:

1. Relation to natural environment.
2. Life and work, or function and life history.
3. Adaptation to work, or form and structure.
4. Comparison and classification.

In the lower grades all emphasis must be placed on the first two or three points; in the intermediate and upper grades more attention is given to structure; in the upper grades classification and practical applications are emphasized.

## RELATION TO LITERATURE.

Plant work can be and should be constantly and very closely related to literature. See "Nature in Verse" and files of *Primary Education*. Refer to works of Longfellow, Whittier, Wordsworth, Holmes, Lowell, and Lucy Larcom.

## FIRST YEAR.

*Special Aim of Work.*—To inspire and develop an interest in and love for the plant as something living, growing, and working, and not a mere form or structure. To learn about the plant as a whole, the relation and work of its parts and its life history, from the seed to the formation of the seed. To lead the child to see how well Mother Nature protects and cares for her children.

*Plant as a Whole.*—One or two whole plants in the early fall (September), to learn about the uses of the root, stem, leaves, and flowers, and particularly about the formation of seeds. A similar study of one plant in late spring (June), as a review. Select common plants, showing the flower and fruit in all stages of development at the same time—such as mallow, buttercup, evening primrose, mustard, sweet peas. Life history of pea or bean in spring (April to June), from seed to formation of seed, to show formation, development, and relations of parts. Plant dwarf varieties in boxes in school-room early in April. Plant some on damp blotters in fruit cans, for study of growth and work of roots. Study each part as it develops. Do not pull up plants or pull them to pieces.

*Seeds and Fruits.*—Formation of seeds from flower, in early fall (September). See list of plants above. Dissemination of seeds (October). Study seeds that fly, such as milkweed, dandelion, thistle; seeds that sail, such as maple, linden, ash; seeds that stick, such as burdock and stick-tight. Fruits (November and December). Study common fruits, such as apple, pear, and orange. Lead to Thanksgiving thought. Germination of seeds (April).

*Buds.*—Development (March to May). Keep twigs in school-room in fresh water, and watch development of one or two at a time. Buds specially good for study are: horse-chestnut, willow, cherry, lilac, beech.

*Leaves.*—Falling and colors of leaves (October and November). Why it is better for them to fall. The work they do on the ground. Nothing about their death. The bright coloring of leaves studied out of doors. Unfolding of "baby leaves" from seed and bud, in connection with seed and bud study (April to June). The way Mother Nature protects the leaves, their arrangement and unfolding, their beauty, and the work they do in beautifying the world.

*Flowers.*—Some kept in school-room and watched (never picked to pieces).

*Special Topics.*—Evergreens studied (December), leading to Christmas thought. Their beauty and adaptation to winter. One tree observed throughout year (one which can be seen from school-room window).

*Field Lessons.*—Whenever possible. The dissemination of seeds and falling and colors of leaves must be studied out of doors in the fall; also the development of buds, the protection and unfolding of baby leaves, and the homes of plants in late spring.

## SECOND YEAR.

*Special Aim.*—Much as in the first year. To review work of first year, strengthening the interest and fixing the ideas gained, but placing a little more emphasis on the way in which parts are fitted for their work—that is, their structure.

*Plant as a Whole.*—Two whole plants, one a composite (September), to show uses of parts, adaptation to work or function, and mutual coöperation. In addition to one or two of the plants named for first year, study dandelion or thistle or burdock plants, their roots, stems, leaves, flowers, fruit. Compare plants studied. Life history, or development from seed to maturity, of bean and pea, with constant comparison, to bring out formation, work and adaptation to work of the different parts, and variations in the form of the same part in different plants (April to June).

*Buds.*—Formation of buds and preparation for winter, in fall. Development, in spring, with more attention to arrangement of parts to be protected and to protect (March to May).

*Seeds, Fruits, and Grains.*—As in first year, but one or two fruits and two or more grains, such as corn, wheat, oats (October and November).

*Leaves.*—As in first year, with some study, in the spring, of the work of leaves for the plant (to guide water to the roots, throw out water, breathe, and make, from air and water, food for the plant), and of the way in which the leaves are fitted for this work. Study parts of leaf and the work of each.

*Flowers.*—Two (one a composite) in fall and two in late spring, to show work of parts (calyx, corolla, and pistil; leave work of stamens and pollen until later) and adaptation to work.

*Special Topics.*—Evergreens, as in first year, but more careful study of adaptation. Two similar trees observed and compared throughout year, to connect or bind together all parts of the plant study.

## THIRD YEAR.

*Special Aim.*—As in lower grades, but placing more emphasis on adaptation to work, as shown in the arrangement, form, and general structure of parts. To make pupils more careful in observation and truthful or exact in expression.

*Plant as a Whole.*—Two simple plants (October) not studied before; with simple description, without technical terms, of the parts, their work and arrangement, form and general structure, as fitting them for their work. Comparison of development from seed to maturity of two dissimilar plants (April to June), such as bean or pea and flax or morning glory.

*Seeds and Fruits.*—Escape of seeds from seed-cases (October) in such plants as plantain, evening primrose, mullein, toad-flax, morning glory, chestnut, mustard, shepherd's purse. Grains and vegetables (turnips, beets, carrots, etc.), their formation by the plant, their use to the plant as a food store-house and preparation for winter, their use to man, all leading to the Thanksgiving thought. Germination, in spring, of seeds more difficult for children to understand, such as morning glory and four-o'clock (April).

*Buds.*—As in second year, with more study of order and plan, and arrangement and form of parts, and with careful detailed drawings (March and April).

*Leaves.*—Position and arrangement on plant, parts and their uses, shape and arrangement of veins, with careful drawings (May).

*Flowers.*—Two in fall and two or three in spring, with comparison, studying position, arrangement, shape, and uses of all parts, and bringing out something of order or plan shown in the flower (May and June). Some tree flowers in May—pistillate, staminate, and perfect.

*Special Topics.*—Evergreens (December), with study of form and structure of parts and distinctive characteristics of the common families, such as pine, hemlock, and spruce. Two dissimilar trees, such as a deciduous tree and an evergreen, observed and compared throughout year.

## FOURTH YEAR.

*Special Aim.*—To gather up and relate the work of the preceding three years and make it a basis for comparison, generalization, and classification. To train the pupils, particularly in the leaf study, in clear, orderly, truthful expression.

*Plants as a Whole.*—One or two in early fall and one or two in late spring, as organs for producing seeds, studying carefully the work, form, and general structure, and coöperation of roots, stems, leaves, and flowers.

*Roots and Stems.*—Forms and structure—morphology (October and June).

*Leaves.*—Arrangement in bud, position and arrangement on plant, attachment, parts, venation, shape, structure, and functions. Careful drawings of leaves and descriptions, using the more simple botanical terms (April to June).

*Flowers and Reproduction.*—Several in fall and spring, bringing out the use and form of parts, including pollen, the process of fertilization, and emphasizing the order and plan shown, leading to comparison and some study of family characteristics.

*Special Topics.*—Observation and comparison of two trees (March to June). Recognition of common poisonous plants, such as poison ivy, nightshade, poison sumach, and wild parsley.

*(Close of First Cycle of Plant Study.)*

## FIFTH YEAR.

*(Beginning of Second Cycle.)*

*Special Work for Year.*—Roots, Stems, and Leaves.

*Special Aim.*—To lay foundations for future plant study by investigating much more thoroughly and expressing much more carefully than in previous years, the development or formation, function or physiology, and form and structure or morphology and anatomy of root, stem, and leaf, as organs of the plant, not as mere forms; to broaden the conception of the plant by studying two flowerless plants.

*Roots, Stems, and Leaves.*—Falling and colors of leaves, with careful observation (October). Development of root, stem, and leaves from seed and bud (April and May). Function or physiology, forms and structure (April to June); with special attention to careful, thorough observation and with truthful, exact descriptions and drawings.

*Flowerless Plants.*—Ferns, including their life history (September). Horse-tails and their life history or reproduction (April and May). Comparison with flowering plants.

*Field Lessons.*—Falling and colors of leaves carefully studied in fall. Position and arrangement of leaves, relation to sunlight and rain, and changes in position and arrangement to aid them in getting sunlight (May and June). Observation of trees (March to June).

## SIXTH YEAR.

*Special Work for Year.*—Flowers and Reproduction.

*Special Aim.*—To give a better understanding of the marvelous processes and adaptations, among flowering and flowerless plants, for producing new plants, and of the care Nature takes of her seeds; to enable the children to absorb from the flower and plant higher, purer, and holier conceptions of reproduction, and of the mystery of the origin of life.

*Roots, Stems, and Leaves.*—Review as much as may seem necessary, in connection with study of flowers.

*Buds.*—Preparation for winter (October and November). Development and structure studied in detail, emphasizing order, plan, and purpose, with careful drawings (March to May).

*Flowers and Reproduction.*—Emphasize work or function of the flower and adaptation to work—that is, study the flower as an organ for producing, protecting, and disseminating seeds.

*a.* Fertilization. How does pollen escape from the anther? How get to the pistil? Study methods of and arrangements for fertilization, the relation of flowers and insects, the use to the plant of the colors, markings, hairs, odors, and nectar of flowers. How does pollen get into the ovary and what does it do there? (September, October, May, and June.)

*b.* Dissemination of seeds. Formation or ripening of seeds and fruit; separation from plant; escape from the ovary; dissemination by fleshy, edible parts, wings and hairy appendages, spines and hooks, springs or elaters, and by water and wind; protection through winter (October and November).

*c.* Family characteristics. Distinctive characteristics of two or three well-marked families in fall, such as composite and mint families, and of one or two families in spring, such as the crowfoot, rose, maple, or violet families. In spring study, as much as possible, tree flowers.

*Flowerless Plants.*—Review fern in September, and horse-tail in April or May, emphasizing reproduction. Learn to recognize other flowering plants, such as mosses, in fall, and liverworts, in spring.

## SEVENTH YEAR.

*Special Work for Year.*—Life History and Classification.

*Special Aim.*—To prepare, by a review of life history, for broader comparison, generalization, and classification.

*Seeds and Germination.*—A careful study of the adaptations for the protection of seeds by neutral colors, by thick, woody coats, by bad tasting or prickly coverings, by fallen leaves, and by snow; of the escape of the embryo from the seed-coats; of the provisions for nourishing the young plant; of the development of root, stem, leaves, and flowers. A review of the whole life history of the plant and of the adaptation of each part to its work—a continuation of the work of the sixth year (April and May).

*Trees.*—Two or three observed throughout year, and a record of their changes kept.

*Classification.*—Distinctive characteristics of three or four families (September, October, May, and June).

*Flowerless Plants.*—Mosses and their reproduction. Comparison with ferns (September). Liverworts and their reproduction. Comparison with horse-tails (May).

## EIGHTH YEAR.

*Special Work for Year.*—Physiology and Morphology.

*Special Aim.*—To study the life processes of the plant; to learn to recognize parts under all forms and conditions, and thus distinguish between essentials and non-essentials; to make broader generalizations and groupings; to broaden the outlook of the pupils.

*Physiology.*—Experimental study of special work, function, or physiology of roots, stems, leaves, and flowers (April to June).

*Morphology.*—A study of the various forms of the same organ, of roots, stems, leaves, and flowers (April to June).

*Classification.*—A careful study, with exact drawings and descriptions, of several plants, emphasizing classification (September and October).

*Flowerless Plants.*—Collection and recognition of lower flowerless plants, such as mushrooms, lichens, and sea-weeds.

## NINTH YEAR.

Work for this year must depend, for some time, on preparatory work done during earlier years; hence it is not outlined in detail. The special aim of the work of this year is to study the plant world in its relations to man, and more particularly the uses man makes of plant products.

## BOOKS OF REFERENCE FOR TEACHERS.

The best book is the book of nature. None of the books named can take the place of the careful study of the plant itself.

| | | |
|---|---|---|
| 1. | Newell's Lessons in Botany, Part 1—Seed to Leaf—Ginn & Co. | $ .55 |
| 2. | Newell's Lessons in Botany, Part 2—Flowers and Fruit—Ginn & Co. | .90 |
| 3. | Newell's Reader in Botany, Part 1—Ginn & Co. | .70 |
| 4. | Newell's Reader in Botany, Part 2—Ginn & Co. | .70 |
| 5. | Hale's Little Flower People—Ginn & Co. | .45 |
| 6. | How to Know the Wild Flowers—Charles Scribner's Sons | 1.50 |
| 7. | Apgar's Trees of United States—American Book Co. | 1.50 |
| 8. | Laurie's How Plants Feed—MacMillan & Co. | .35 |
| 9. | McDougal's Plant Physiology—Henry Holt & Co. | 1.00 |
| 10. | Spaulding's Introduction to Botany—D. C. Heath & Co. | .90 |
| 11. | Bergen's Glimpses of Plant World—Lee & Shepard. | .75 |
| 12. | Pratt's Fairyland of Flowers—Educational Publishing Co. | 1.50 |

Nos. 1 and 2 are helpful in all general study of structure.

Nos. 3, 4, and 5 tell about plant life, work and adaptation to work.

Nos. 6 and 7 aid in identifying flowers and trees.

Nos. 8, 9, and 10 are helpful in the study of plant physiology.

No. 11 treats largely of the flowering plants.

No. 12 is good for classification and literature.

# Animal Study.

## AIM.

Too much emphasis cannot be placed on the aim of all nature study, as stated in the introduction. The aim of the animal work is, before all else, to arouse an interest in and cultivate a sympathy for the animals about us, and through this interest and sympathy to develop among the children a higher appreciation of what we receive from and owe to the animals. To accomplish this, the study of animals must be, mainly, a study of living animals, of action and adaptation to function, rather than of mere form and structure.

## ORDER OF STUDY.

1. Relation to natural environment, homes and home life.
2. Habits, observed in school-room.
3. Work or function of parts, and adaptation of structure to function.
4. Life history.
5. Comparison and classification.

This order of study is based on the following principles:

1. That we should begin with that in which children are most interested, and which is most like themselves—life and action.

2. That at the very beginning we should relate our school work to the out-of-door life of the children.

3. That we should always approach structure from the higher side—that of function or purpose—and study structure as an adaptation to special work or function.

4. That the relation to environment and adaptation of structure to function is best understood when we have studied life history, or development from egg to adult.

5. That we should broaden the ideas gained by observation, by relating the animals studied, and making the animals seen, types of those not seen.

NOTE.—For convenience in discussing the work, the animals studied each year are grouped in their zoölogical divisions, following the simplest classification: Vertebrates, or back-boned animals; articulates, or animals with jointed bodies; mollusks, or soft-bodied animals; and radiates, animals with parts radially arranged.

## FIRST YEAR.

*Aim.*—To interest children in the life and habits of animals. Only living animals studied.

### ARTICULATES.

*Insects.*—Caterpillars and butterflies (in September). Milkweed and cabbage butterflies are best, as their transformations can be readily watched. The dark brown, hairy (Isabella) caterpillar and the yellow (woolly bear) caterpillar are good for the study of habits.

Keep caterpillars in cans or tumblers covered with netting or in wire-netting boxes. Study habits and movements, feeding and food, breathing and spinning of caterpillar, formation of cocoon, transformation to butterfly or moth, and movements, feeding, and breathing of adult.

Dwell on beauty of form, color, and adaptation, and on symbolism of the transformation or metamorphosis.

### MOLLUSKS.

*Snails.*—Pond snails and land snails (in October and November). Gather early, keep in glass cans, and have children watch habits, movements, feeding and food, breathing, protection, and, when eggs are deposited in cans, life history. Make structure incidental.

### VERTEBRATES.

*Fish.*—Gather minnows in October, keep in school-room and have children watch habits. Study adaptation to their life and work (November).

*Birds.*—Watch for birds in April. Children should learn to recognize two or three. Study and talk about their homes and habits, nesting, songs, eggs, feeding and protecting young. A canary in school-room may be helpful.

*Field Lessons.*—Homes of insects, galls, leaf-miners, leaf-rollers, in September. Two or three common birds, robin, bluebird, oriole, sparrow, in May.

## SECOND YEAR.

*Aim.*—To review and "clinch" work of first year, with a little more attention to structure. Only living animals studied.

### ARTICULATES.

*Insects.*—Caterpillars and butterflies, with more careful study (September). Crickets kept in wire cage or cans, and movements, feeding, breathing, and chirping investigated. Main divisions and appendages studied and compared with those of grasshopper (September). Galls and leaf-miners—homes of insects—studied a little in October.

*Spiders.*—Kept in cans or bottles, and habits observed. Emphasize spinning habits and web. Compare divisions of body and appendages with those of insects. Gather cocoons or egg-cases and talk about life history (September and October).

### MOLLUSKS.

*Snails.*—(October.) Review habits, study parts and their use, shell and its formation from lime, and lead to fossil shells and limestone.

*Clams.*—Only shells studied (November); shape and formation from lime, as a preparation for fossils and limestone.

VERTEBRATES.

*Fish.*—Sunfish and horn-pouts, or "bullheads," are readily kept (November). Habits and adaptation to life.

*Amphibians.*—Frogs. Eggs and tadpoles gathered in April and development watched (April to June).

*Reptiles.*—Turtles, if obtainable, studied in November—habits, adaptation to life, or their structure, protection, life history.

*Birds.*—Two or three. Note their return, nesting, feeding young, songs. Note how they are fitted for their life (April to June).

*Mammals.*—One domestic animal, such as cat, dog, cow, horse (November).

## THIRD YEAR.

*Aim.*—To help pupils understand and lead them to think about the ways in which animals are fitted for their life and work. Some classification.

RADIATES.

*Corals.*—Occurrence, general structure, and adaptation to life; work in earth-making (December).

ARTICULATES.

*Insects.*—As before, with more attention to structure and comparison. Classify insects as sheath-winged, scale-winged, two-winged, etc. Select insects not studied before (September).

*Spiders.*—As before (October and November). Compare with harvest men.

*Crustacea.*—Crayfish. Keep in glass tank and cans. Study home, movements, feeding, breathing, adaptation to life, general structure. Compare with lobster and crab (October).

VERTEBRATES.

*Fish (or Frogs or Turtles).*—With more emphasis on structure (November).

*Birds.*—From habits and structure lead to classification as scratchers, waders, swimmers, etc. Study life history (May and June).

## FOURTH YEAR.

*Aim.*—To gather up, review, "clinch" and arrange the ideas gained during the first four years.

RADIATES.

*Corals.*—In review, studying varieties and leading to fossils and limestone (November).

*Starfish.*—General structure. Read or talk about home, life, and habits. Adaptation of structure to life. The starfish as a type of the radiates. Compare with sea-urchin (November).

ARTICULATES.

*Worms.*—Earthworms, homes, habits (movements, food, burrowing), value to man, general structure, including segments, legs, blood vessels and alimentary canal (visible through skin). (October.)

*Insects.*—Any insect not previously studied. Aquatic insects good. Emphasize life history, structure, and classification (September).

*Crustacea.*—Crayfish, habits, general structure, life history, comparison with sowbug, lobster and crabs (September and October). Classification of arthropoda (October).

VERTEBRATES.

*Birds.*—With more attention to classification (May).

*Mammals.*—One or two compared with any other class of vertebrates. Classification of vertebrates (November).

*General Classification.*—Classifying all animals studied during the four years (December and June).

*(Close of First Cycle of Animal Study.)*

## FIFTH YEAR.

*(Beginning of Second Cycle.)*

*Special Work.*—Articulates or jointed animals, including the arthropoda or jointed limbed animals and the vermes or worms.

ARTHROPODA

(September to December).

Includes insects, spiders, crustacea, and myriopoda.

ORDER OF STUDY.

*Life History.*—A careful study of the life history of two not studied before. The development of the mosquito or fly can be readily watched (September).

*Relation to Environment.*—Occurrence, homes, food, habits, studied in field lessons as much as possible. Children encouraged in out-of-door observations. Living animals kept in school-room (September and October).

*Relation to Man.*—Injurious and beneficial insects; value of the spider; use of crayfish, crab, and lobster for food.

*Structure and Comparison.*—Study carefully, draw, and describe carefully and fully at least one animal belonging to each of the four divisions of arthropoda, and compare with the others.

*Classification and Related Forms.*—Study *distinctive* characteristics of insects and of their most common orders, and of other classes of arthropoda. Put all emphasis on *distinctive* characteristics. During November

and December broaden ideas of pupils by reading about related animals. Give meaning of all names used. Use common names whenever possible.

VERMES

(October and November).

*Worms.*—Begin with earthworm as type. Keep in earth in boxes in school-room, and investigate habits. Tell about development from egg. Study out of doors castings and burrows. Read (see Darwin's Vegetable Mould and Earthworms) about its relation to man. Study carefully its structure, form, ends, segments, legs, and the adaptation of structure to function; also internal structure, so far as visible externally, such as blood vessels, circulation and alimentary canal. Compare with other worms. *Distinctive* characteristics of worms. Compare with those of arthropoda. Characteristics of articulates.

## SIXTH YEAR.

*Special Work.*—Mollusks, Radiates, Birds.

MOLLUSKS

(September to November).

*Life History.*—Watch development of snails from the eggs. Tell about the development and growth of the clam.

*Relation to Environment.*—Keep snails and, if obtainable, small clams in the school-room, and investigate their movements and habits. Encourage and lead pupils to watch snails (water and land), slugs, and clams out of doors and to report on their habits. Touch on fossil shells and their story.

*Relation to Man.*—Use for food in different parts of the world.

*Structure and Comparison.*—Study, draw, and describe carefully the structure of the snail. Compare different kinds of snails. Study the general structure of the clam; it is too difficult for detailed study. Compare with oyster, if possible. Compare with snail.

*Classification and Related Forms.*—The *distinctive* characteristics of the three most common classes of mollusks—snails (univalves—gastropoda), clams (bivalves—lamellibranchiata), and squids (cephalopoda). Points in which all are alike—that is, characteristics of mollusks. As opportunity comes, during the winter, pupils should read about the sea snails and clams, the devil-fish and other mollusks, to broaden their ideas. Give meaning of all names.

RADIATES

(November and December).

*Corals, Starfish, and Sea Urchins.*—Read and talk about their occurrence and habits, and the formation of coral reefs. Study, from pictures and specimens, their general structure (of living animals and of their skeletons). Emphasize the *distinctive* characteristics of each, the points in which corals are unlike the others, and the points in which all are alike (general plan), from which they get the name radiates.

### VERTEBRATES — BIRDS
(March to June).

*Life History.*— Watch in the school-room the development of the frog from the egg. This will form a basis for the study of the development of the bird in the egg.

*Relation to Environment.*— Have children study out of doors the habits of the birds, their coming, during March and April, their nest-building, songs, and feeding habits, during May and June. Keep a live bird (canary) in school-room and investigate its habits.

*Relation to Man.*— The value of the birds to man, the beauty of song and plumage, the great good they do in destroying insects, the little injury they do to buds, fruits, and grains.

*Structure and Comparison.*— Study as much as possible from living birds, constantly relating structure to function. Compare typical scratchers (chicken), swimmers (geese), perchers (canary), climbers (woodpecker), and waders (snipe). (May and June.)

*Classification.*— Bring out *distinctive* characteristics of common natural orders of birds, the characteristics which all birds have in common, and the characteristics which show that they are vertebrates (June).

## SEVENTH YEAR.

*Special Work.*—Vertebrates.

### FISHES, TURTLES, AND MAMMALS
(September to November).

*Life History.*—Development of fishes and reptiles will, doubtless, have to be told to pupils.

*Life and Habits.*—Fishes, turtles, and mice or squirrels can be kept in school-room. The habits of many other mammals can be readily investigated out of doors.

*Structure and Comparison.*—Should be emphasized and some study made of internal structure, and particularly of the skeleton. This can be made very helpful in the study of human physiology.

*Classification and Related Forms.*— Each form studied must become a type for related animals, about which pupils should read during the winter. *Distinctive* characteristics of common orders of mammals, such as carnivorous mammals; rodents, or gnawers; ungulates, or hoofed animals.

### FROGS AND BIRDS
(April to June).

Frogs are particularly good as a study of life history and development. Study also their structure and adaptation of structure to life and function during different periods of life.

Birds are interesting and valuable as a basis for the study of habits and of classification.

*Review.*—During the late fall and early spring the classification of animals should be reviewed and "clinched."

## EIGHTH YEAR.

No animal work outlined for this year. In planning for a nine-year course it has been thought best to give all possible attention to plants during the eighth year and to animals during the ninth year. In an eight-year course the animal study outlined for the ninth year can be combined with or substituted for the plant study indicated for the eighth year.

## NINTH YEAR.

*Special Work.*—Insects and Birds—Review.

*Insects.*—Special study, emphasizing structure, classification, and relation to man. Beneficial and injurious insects. Collection and classification of insects by pupils (September to November).

*Birds.*—Special study of habits, structure, and classification of birds, emphasizing their value to man (April to June).

*Mammals.*—If preferred, a study of mammals can be made, with careful dissection of one or two, either as a basis for the study of human physiology or for the classification of mammals.

*Review.*—Classification of invertebrates (September to November). Classification of vertebrates (April to June).

## BOOKS HELPFUL IN ANIMAL STUDY.

1. Morse's First Book of Zoölogy—American Book Co. . . . . . . . . . . . . . . $ .90
2. McCook's Tenants of an Old Farm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1.50
3. Colton's Practical Zoölogy—D. C. Heath & Co. . . . . . . . . . . . . . . . . . . .85
4. Our Common Birds and How to Know Them—Chas. Scribner's Sons 1.50
5. Ballard's Moths and Butterflies—George Putnam's Sons . . . . . . . . . . 1.50
6. Entomology for Beginners—Henry Holt & Co. . . . . . . . . . . . . . . . . . . . 1.40
7. Guides for Science Teaching—D. C. Heath & Co. . . . . . . . . . . . . . . . . . —

No. 1 is general, very simple, definite and practical; particularly helpful in study of snails, clams, and insects.

No. 2 relates to habits of insects and spiders.

No. 3 is a manual for study of structure.

Nos. 4, 5 and 6 are most helpful in the study of birds, moths and butterflies, and insects, respectively.

Under No. 7 are included a series of guides, varying in price from ten cents to one dollar, helpful mainly in the study of structure.

# Minerals, Rocks, and Geology.

## INTRODUCTION.

During the first cycle (first four years) the work is limited to the study of the common earth-forming rocks ("earth materials"), and the processes by which these have been formed and are being changed. The study is pursued mainly as a preparation for geography.

During the second cycle minerals are considered mainly in their economic or practical relations, their use to man, and their occurrence, mining, transportation, and uses are studied.

Considerable attention is given to rock disintegration and soil-making, and to the work and effects of rain, waves, streams, and ice in wearing away, transporting, and depositing materials. In this work and in the study of water, air, and heat, as outlined in the course in Physics, the pupils investigate the "earth processes," the processes by which the earth has been and is being changed, and gain some idea of the life of the earth.

## FIRST YEAR.

No work with minerals. Living nature, plants and animals, and the forms of water have been found more attractive and better adapted to pupils of this grade.

## SECOND YEAR.

*Object of Work.*—Mainly to interest children in and to give them some understanding of the life history of limestone, sandstone, and soil—the story they tell of changes, and the cause of these changes.

*Limestone.*—Formation, distinctive characteristics, fossils, and crystals (November and December). Lead from study of snails (in animal study), and the formation of the shells of snails and clams, to the fossil shells in the limestone and their story. Or from the study of the formation of crystals (use blue vitriol, alum, and rock candy) lead to the crystals in the limestone, and the story they tell of the way in which the limestone has been formed. In both these lines of thought the children should bring to school and study teakettle incrustations. They will help them to understand how limestone has been formed.

*Sandstone.*—Begin with quartz, emphasizing its hardness (scratches glass easily) and glassy appearance. Study or tell about quartz crystals, and show how crystals are formed. Lead from quartz to sand, which is merely broken up or finely crystallized quartz. Show how sand can be

fastened together by lime or by iron. (Keep for a week or more a rusty piece of iron in damp sand.) Study sandstone — first, coarse-grained sandstone, showing that it is made of pieces of quartz, and later finer grained stone. Show, by experiment, how water stratifies materials or arranges them in layers, and touch on the story told by the stratification or layers of sandstone.

*Soil-making.*— Collect "rotten" limestone and sandstone, showing that they do break down into soil. Call attention to the cracks in rocks into which water soaks. Show, by experiment, how water expands when freezing and how the freezing of water breaks the rocks, and tell how the roots aid the water. Study in May the decaying leaves in gutters, and the different stages in the change from leaf to soil (October, November, April, and May).

*Field Lessons.*— Collect rocks in fall. Study leaves and rock disintegration in spring.

## THIRD YEAR.

*Object of Work.*—As in second year, but with more attention to structure and distinguishing characteristics.

*Limestone.*—Review work of previous year, leading to story of formation of limestone from corals and shells (see animal study). (November and December.)

*Sandstone.*— Quartz, sand, and sandstone, as in second year, but with more varieties, including fine-grained sandstones and shales and several varieties of quartz. Study their story carefully and emphasize distinctive properties (January).

*Granite.*— Feldspar, hornblende, and mica, their distinctive properties and uses ; their combinations, with quartz, into granite. Binary and ternary granite. Uses of granite (January).

*Soil-making.*—As in second year, but more carefully.

*Work of Water—Formation of Valleys.*—Study what the water does with the soil—how it wears it away, carries it along and deposits it. Study, after a rainstorm, formation of rills and gullies, and the transportation and deposit of material (October, November, April, and May).

*Field Lessons.*— Collection of rocks (October and November). Formation of soil and work of water (October, November, April, and May).

## FOURTH YEAR.

*Special Object.*—A more thorough study of common earth-forming minerals, their occurrence, formation, properties, common varieties, and uses.

*Limestone.*— Emphasize the study of fossils and their story, the varieties of limestone (calcite, chalk, tufa, marble) and their formation, distinctive characteristics and uses, the manufacture and uses of lime (December).

*Sandstone and Stratified Rocks.*—Varieties and uses of sandstone. Stratified rocks, their characteristics, occurrence, and the story of their formation (December and January).

*Granite and Crystalline Rocks.*—Their constituents (properties, varieties, and uses of each) and the story of their formation, by heat (January

*Formation of Soil and Work of Water.*—Studied in field. Study a brook and its basin (October, or April and May).

*Field Lessons.*—Collection of fossils, minerals, and rocks of vicinity (September to November). Formation of soil and work of water (October and November).

## FIFTH YEAR.

*Common Minerals.*—Their occurrence, formation, properties (emphasizing distinctive properties), varieties, manufacture, and uses. Calcite, or limestone, and quartz, feldspar, hornblende, and mica are supposed to have been studied during third and fourth years. If not, begin with these, the most abundant minerals. Other minerals suggested are: Graphite, sulphur, pyrite (iron pyrites), chalcopyrite (copper pyrites), galenite (lead ore), gypsum, talc (soapstone), halite (common salt), hematite and limonite (iron ores). Additional important, but less common, minerals are: Sphalerite (zinc ore), barite, magnetite (magnetic iron ore), cuprite (copper ore), serpentine, and chlorite. The ores, particularly those of iron, their occurrence, mining, manufacture, and uses, will be studied in detail during the seventh year (November and December).

## SIXTH YEAR.

*Coal.*—An intensive study of coal, beginning with the study of peat and, if possible, of a peat bog, as a preparation for the investigation of the formation of coal, taking up the place and manner of occurrence, particularly in United States, its properties and varieties, the process of mining and preparing for market, the transportation (methods and routes), and the uses and great commercial importance of coal. The coal should thus become a center for a study of commerce (November and December).

*Earth-making Forces.*—Water, air, and ice, and their work as geographical agents in forming soil and sculpturing the surface of the earth. Field lessons during October and November and March to May.

## SEVENTH YEAR.

*Iron Ores and Iron.*—An intensive study. The occurrence, formation, properties, varieties, mining and reduction and transportation of iron ores; the manufacture, properties, varieties, and uses of iron; the process of manufacture of rails, stoves, and other materials made of iron; the economic importance of iron, and relation between the progress of a country and its stores of coal and iron. Iron thus becomes a center for the study of the industrial development of the country. If there is time, copper, lead, and zinc can also be studied (November and December).

NOTE.—The work in minerals ends with the seventh year, all the winter months in years eight and nine being devoted to physics and chemistry.

## BOOKS ON MINERALS AND GEOLOGY.

1. Shaler's First Book of Geology—D. C. Heath & Co. . . . . . . . . . . . . . . . . $1.10
2. Geikie's Elementary Lessons in Physical Geography—MacMillan & Co. . . 1.00
3. Geikie's Study of Geography—MacMillan & Co. . . . . . . . . . . . . . . . . . . .65
4. Crosby's Common Minerals and Rocks—D. C. Heath & Co. . . . . . . . . .65
5. Clapp's Observation Lessons on Minerals—D. C. Heath & Co. . . . . . . .30
6. Kingsley's Town Geology—MacMillan & Co. . . . . . . . . . . . . . . . . . . . . .65
7. Kingsley's Madam How and Lady Why—MacMillan & Co. . . . . . . . .65

No. 1 treats of the world as a workshop, describes processes, tells how soil is made, how valleys are worn, how coal is formed, how fossils are deposited. It tells the story of the life of the earth.

In No. 2 Dr. Geikie tells the story of the life of the earth, and in No. 3 tells how to study this story out of doors, as well as in the school-room.

No. 4 treats of the properties and distinguishing characteristics of common minerals and rocks.

No. 5 describes the plan, followed very successfully in a Boston grammar school, for studying minerals.

No. 6 discusses the story and study of minerals of economic importance—coal, marble, brick, granite.

In No. 7 the children are taken out of doors to study the story of the formation of hills and valleys and other natural features, and of the materials composing them.

# Physics and Chemistry.

## REMARKS.

The work during the first four years is entirely a study of "earth forces," pursued as a preparation for geography. The work of the last four years is considered more in its practical or economic bearings.

## FIRST YEAR.

### WATER: ITS FORMS AND WORK

(February and March).

*Uses of Water.*—To man, animals, and plants. Why so useful.

*Evaporation.*—Study evaporation from vessel not heated, more rapid disappearance of water from vessel on radiator, and still more rapid evaporation from vessel heated over alcohol stove. Meaning of evaporation, and effect of heat on rate of evaporation. Application to drying of wet desk, blackboard, cloth, sponge, sidewalk, roof, clothes, etc.

*Condensation.*—Condense with cold object vapor and water-dust from teakettle, and from vessel over radiator. Effect of cold on vapor and water. Illustrate with breath and windows.

*Forms of Water.*—Application to explanation of fog, cloud, dew, rain, frost, snow. Make these more than mere forms of water, by bringing in the literature of rain, clouds, frost, snow, studying the beauty and work of each and personifying them in stories.

## SECOND YEAR.

### WATER.

As in first year, but more thoroughly (February).

### AIR AND WINDS

(March).

*Presence of Air.*—Demonstrate by experiments with bottles and cans and water.

*Uses of Air.*—Show by experiment that air is necessary for burning or combustion. Apply to lamp and stove. Bring out necessity of air for breathing of animals and plants.

*Currents of Air.*—Show by experiment how currents of air are produced by heating the air. Application to ventilation. Winds. Explanation of winds. Relation between direction of wind and weather. Uses of winds.

## THIRD YEAR.

### HEAT: ITS SOURCES AND EFFECTS

(February and March).

*Sources of Heat.*—Combustion, friction, chemical action, and the sun. Under combustion investigate constitution of substances which burn, showing that they contain carbon and contain or form gases, and demonstrate necessity of air for combustion. Apply to study of fuel and of lamps, stoves, and furnaces. In studying sun as a source of heat, bring out, by observation, the fact of the varying obliquity of the sun's rays at different parts of the day and at different seasons, and the effect of this on the amount of heat received from the sun. Explain by experiment.

*Effects of Heat.*—Heat changes state of bodies from solids to liquids or gases. This will include a review of evaporation and condensation and of the forms of water. Heat causes expansion of bodies, of solids, liquids, and gases. Demonstrate by experiment. Apply to explanation of thermometer, steam engine, and winds.

## FOURTH YEAR.

### HEAT: PRODUCTION, CONDUCTION, CONVECTION, RADIATION, ABSORPTION, AND EFFECTS

(February and March).

*Production.*—A review of work of previous year.

*Conduction.*—Conducting power of different metals. Good and bad conductors. Application to clothing. Conduction in liquids.

*Convection.*—Explanation. Necessity and use of currents in liquids and gases. Application to winds.

*Radiation.*—Process. Good and bad radiators. Law of distance. Applications to cooling of earth.

*Absorption.*—Absorptive power and specific heat. Application to warming of land and water.

*Effects of Heat.*—Largely a review of work of previous year.

## FIFTH YEAR.

### GRAVITATION

(January).

Fact and law of gravitation, with illustrations. Center of gravity, brought out by experiments with sticks, cardboard of various shapes, and solids.

*Equilibrium.*—Relation to position of center of gravity. Kinds—stable, unstable, and neutral. Practical applications.

*Pendulum.*—Relation to gravitation. Relation between length and number of vibrations. Use in clocks.

PRESSURE OF FLUIDS: HYDROSTATICS, PNEUMATICS, AND SPECIFIC GRAVITY

(February and March).

*Pressure of Liquids.*— Direction, transmission, relation between depth and amount of pressure, specific gravity, buoyancy. Application to hydraulic presses and elevators, and to leveling instruments.

*Pressure of Gases.*— Pressure of air. Comparison with pressure of liquids. Application to explanation of air currents, winds, barometer, and pumps.

## SIXTH YEAR.

PROPERTIES OF MATTER — CAPILLARITY AND OSMOSIS

(January).

*Properties of Matter.*—Molecules and atoms. Porosity, compressibility, elasticity, tenacity, hardness, ductility, malleability, and other properties.

*Capillarity and Osmosis.*—Cohesion and adhesion. Experiments with water and mercury with tubes of different diameters. Applications, emphasizing importance in plant and animal physiology.

MECHANICS

(February and March).

*Levers.*— Parts, kinds, laws, practical applications.

*Wheel and Axle* and practical applications.

*Inclined Planes* and applications.

*Machinery.*— Sewing machine, engine, etc.

## SEVENTH YEAR.

MAGNETISM (January).

SOUND AND LIGHT (February and March).

## EIGHTH YEAR.

ELEMENTS OF CHEMISTRY (November to January).

MAGNETISM AND ELECTRICITY (February and March).

## NINTH YEAR.

CHEMISTRY OR PHYSICS (November to March).

Chemistry, or a careful study of one subject in Physics.

NOTE.— The work for the last three years has not been planned out in detail. Pupils have not been prepared to take it up.

## BOOKS ON PHYSICS.

1. Shaw's Physics by Experiment—Effingham, Maynard & Co.......$1.00
2. Worthington's Physical Laboratory Practice—John Allyn........ 1.20
3. Bert's First Steps in Scientific Knowledge—J. B. Lippincott Co.. 1.00
4. Bailey's Inductive Elementary Physical Science—D. C. Heath & Co. .40
5. Hotze's First Lessons in Physics—Columbian Book Co............ .75
6. Hammel's Observation Book in Physics—American Book Co..... .30
7. Mayer's Sound—D. Appleton & Co............................. 1.00
8. Mayer & Barnard's Light—D. Appleton & Co.... ............ .. 1.00

# HISTORY AND LITERATURE.

## INTRODUCTION.

Literature is but a department of history. It interprets the spirit and character of a historic period, and constitutes an important element in the history of that period. The folk lore, fairy tales, and legends bring to us a knowledge of the age and the people with whom they had their origin. In an important sense they were a part of the literature of the time, and they have come down to us through many generations, to charm both young and old by their quaintness, their simplicity, and their appeal to human sympathy and human interests. It is the spiritual element in them that entitles them to a worthy place in literature, and it is this element that makes them valuable as an educational force in the work of the school.

We have but to remember the fancies of our childhood, or to observe the children about us, to satisfy ourselves of the adaptation of this kind of literature to the young. At this time of life the imagination is the most active. Among the pastimes of our childhood were the conversion of the ever-shifting, flying clouds into armies in battle array, into all manner of animate creatures, beasts of prey, gods and heroes, or vast landscapes, skirted by grand mountains and fathomless abysses. In the glowing embers we saw spirits and fairies dancing in merry glee. We made all inanimate nature contribute to our fancy, clothing it with the habiliments of life and action. When there was not anything better to serve our purpose, out of nothing we created something and gave it the breath of life. These fanciful creations became our boon companions, with whom we chatted and coquetted and who were made to do our bidding, coming and going, living and dying, just as best suited our fancy. This was the atmosphere in which we lived, moved, and had our being.

As our childhood was, so is the childhood of to-day. If the task of educating such children is given to us, we must take them as we find them, and adapt our methods to their conditions and demands. This imagination is given them for a purpose, and it becomes our duty to give it proper bent

and make good use of it in the building up of character. It is often neglected or even suppressed, greatly to the disadvantage of the future man or woman. The person whose imagination has been ground out of him, and who lives in a purely matter-of-fact world, loses much of the enjoyment of life, to say nothing of his loss of power to give it to others. It becomes us, then, as teachers to cultivate this element of human character, to give it proper nourishment and growth, that it may serve its purpose and do its work in the drama of life. These stories and legends are the fitting introduction to history and literature. They may, in fact, be properly considered a part of it—the elementary stages.

Care should be taken in the selection of this material. Only those stories should be selected that have a direct bearing on the effort to build up a strong, well-rounded character—that have good ethical point and influence. The child must be left to draw his own inferences. He should not be required to express the significance of the story by any formal interpretation, but the spiritual essence, the moral lesson, must be left to work its silent, ever-pervasive influence, as a spiritual atmosphere. The inner life and experience must be touched and revealed in sympathetic emotion. In this way spiritual growth is induced. As a result of this spiritual awakening, reflections follow, and these result in generalizations.

The interest of the child is important and must be secured, and this is a strong argument in favor of the use of this kind of literature for children. But mere diversion or interest is not sufficient; there must be in it a spiritual element that takes hold of the life of the child, touching a sympathetic chord that gives ready response and adds a valuable increment to character. This is our plea for legends and fairy stories as the elementary steps in a well-arranged course in history and literature.

But this is not all. They are not only well calculated to awaken thought, arouse interest, quicken inner perception and reflection, and so bring the mind into a receptive condition, ready to assimilate, and induce growth and strength, but they give the most fitting opportunities for the cultivation of expression in its best forms and in variety. This part of the work should by no means be neglected. It should be emphasized as an essential thing in the training of the child. Every thought and every emotion should have its fitting expression. Abundant opportunities are here afforded for the exercise of expression in all its varied forms—by pantomime, by drawing and painting, by moulding and building, as well as by oral and written expression. It must ever be borne in mind that the expression of an idea is quite as important in the education of the child as its inception. Expression always tends to quicken thought and perfect it, and without expression it renders no service. The giving of suitable ex-

pression should, then, take equal rank in importance with the awakening of thought.

More, I am sure, need not be said in defense, if defense is necessary, of this line of work in our schools. To us it seems essential as a basal element—one of the main foundations on which to build. We believe it to be more important and effective in the training of the child than the physical sciences. It brings the child into more immediate touch with the spiritual, living forces of the world. Here it is that he sees the bearing of conduct on life. He learns to trace moral effects to their sources. He observes here springs of human actions. He sees human nature in all its phases, and learns how to interpret it. No better lessons can be given in the way of moral training—nothing is better calculated to fit for the real activities of life. Living, acting, spiritual beings, with thoughts, feelings, and emotions which find a ready response in his own life, arouse an interest and give a culture product which mere nature studies cannot produce. We believe both lines are essential in a well-arranged curriculum, but no more serious mistake can be made than to leave out the humanity side.

It is true that the nature studies awaken interest and give abundant opportunities for the cultivation of expression, but we have always found that the historic lines of study arouse the most intense interest and enthusiasm, and never fail to induce regular attendance and secure the closest attention. The children take the keenest delight in reproducing the stories, whether orally or in writing. As will be seen, this course terminates in the mature form of history and literature.

E. A. SHELDON.

# History and Literature.

## PLAN OF PRESENTATION.

In all the lower grades the matter is presented by the teacher in the form of a story. After a part of the matter has been presented, a pupil is asked to stand before the class and reproduce what has been given. Great care should be taken that too much matter is not presented before a reproduction is called for.

During the presentation questions are asked which will lead the children to express their thoughts in regard to characters described or facts related, or to make inferences in regard to the further development of the story. During the reproduction the teacher corrects any mistakes in the use of language.

When the children are of suitable age, at stated times written reproductions of the story, or some part of it, are required. In this exercise great care is given to all details of form and arrangement.

A representation of some object connected with the story is frequently made by the pupils with either pencil or brush. The children take great pleasure in this work, and even the youngest are given some of it to do. The younger ones also delight in reproducing parts of a story in pantomime.

Much illustrative material is used. This consists of natural objects, mouldings in sand, stereopticon views, and pictures. Rapid, rough sketching by the teacher is of great service in this connection.

Poems or bits of prose which are related to the story told, are often introduced into the work, These are read to the pupils, and sometimes a quotation is memorized. Part of the original from which the story is selected is often treated in the same way. An example of this is found in the use of passages from Bryant's translation of Homer's Iliad, in the fourth year, or in the use of the poem "How the Leaves Came Down," immediately after the story of "The Anxious Leaf" has been told, in the first year's work. Teachers are often surprised to find, in connection with this work, that children appreciate that which might seem much beyond them.

Success in this work depends largely upon a teacher's knowledge and appreciation of literature, a large vocabulary, and a well-trained voice and body. To do this work in an ideal way one needs to be a teacher, a student of literature, an artist in the use of language, and something of an actor.

## C PRIMARY—First Year.

### FOLK LORE.

#### Stories.

1. Jack and the Beanstalk: *Lang's Red Fairy Book.*

2. The Anxious Leaf: *Classic Stories for Little Ones*, Mrs. McMurry.

3. The Three Bears: *Fables and Folk Stories*, H. E. Scudder.

4. Tom Thumb: *Lang's Red Fairy Book.*

5. The Street Musicians: *Grimm's Fairy Tales; Classic Stories for Little Ones*, Mrs. McMurry.

6. Red Riding Hood: *Lang's Red Fairy Book; Classic Stories for Little Ones*, Mrs. McMurry.

7. Why the Hare has Long Ears: *Popular Science Monthly, October, 1894.*

8. Cinderella: *Lang's Red Fairy Book; Classic Stories for Little Ones*, Mrs. McMurry.

9. Dick Whittington's Cat: *Fables and Folk Stories*, H. E. Scudder.

10. Birds of Killingworth: Arranged from *Longfellow's Poems.*

## B PRIMARY—Second Year.

### FAIRY TALES AND MYTHS.

#### Stories.

1. The Flax: *Andersen's Fairy Tales.*
2. The Buckwheat: *Andersen's Fairy Tales.*
3. The Ugly Duckling: *Andersen's Fairy Tales.*
4. The Snow Man: *Andersen's Fairy Tales.*
5. The Goblin's Gift: *Popular Science Monthly, October, 1894.*
6. The Snow Queen: *Andersen's Fairy Tales.*
7. Sleeping Beauty: *Andersen's Fairy Tales.*
8. The Pea Blossom: *Andersen's Fairy Tales.*
9. Hiawatha: *Longfellow's Poems.*
10. Toomai of the Elephants: *Kipling.*
11. Her Majesty's Servants: *Kipling.*

## A PRIMARY—Third Year.

### MYTHS.

#### Stories.

1. Saturn: *Gods and Heroes*, Francillon; *Myths of Greece and Rome*, Guerber.

2. Jupiter: *Gods and Heroes*, Francillon; *Myths of Greece and Rome*, Guerber.

3. Pandora: *Hawthorne's Wonder Book.*

4. Persephone: *Hawthorne's Wonder Book.*

5. Phæton: *Bulfinch's Age of Fable.*

6. Flower Myths—(a) Laurel; (b) Clyte: *Gods and Heroes,* Francillon.

7. Labors of Hercules—1st, 2d, 5th, 6th, 11th: *Gods and Heroes,* Francillon.

GENERAL REFERENCES.—*Age of Fable,* Bulfinch; *Classic Myths,* Gayley.

## C JUNIOR—FOURTH YEAR.

### HEROIC STORIES.

**Stories selected from Homer's Iliad.**

1. The Apple of Discord.
2. The Quarrel of the Chiefs.
3. The Battle of the Plain.
4. Hector and Andromache.
5. The Building of the Wall.
6. The Embassy to Achilles.
7. The Meeting of the Chiefs.
8. The Battle at the Wall.
9. The Battle at the Ships.
10. Patroclus.
11. The Rousing of Achilles.
12. The Death of Hector.
13. The Ransoming of Hector's Body.
14. The Taking of Troy.

REFERENCES.—Bryant's translation of *Homer's Iliad;* Lang's trans - tion of *Homer's Iliad;* Bryant's translation of *Virgil's Ænid.*

## B JUNIOR—FIFTH YEAR.

### HEROIC STORIES (CONTINUED).—FIRST TERM.

**Stories selected from Homer's Odyssey.**

1. The Cyclops.
2. The Island of Æolus.
3. Circe.
4. The Song of the Sirens.
5. Scylla and Charybdis.
6. Telemachus.
7. The Trial of the Bow.

REFERENCES.—Bryant's translation of *Homer's Odyssey;* Lamb's *Adventures of Ulysses.*

## B JUNIOR—FIFTH YEAR.

### NORSE MYTHOLOGY.—SECOND TERM.

**Stories.**

1. Odin.
2. Balder.
3. Siegfried.
4. Grayfell.
5. The Dragon.
6. Brunhild.

REFERENCES.—*Myths of Norse-Land,* Guerber; *Norse Mythology,* Andersen; *Story of Siegfried,* Baldwin.

## A JUNIOR—Sixth Year.

### HISTORICAL STORIES.

**Stories.**

1. Battle of Thermopylæ.
2. Pericles.
3. Julius Cæsar.
4. Charlemagne.
5. Alfred the Great.
6. Peter the Hermit.
7. Richard Cœur de Lion.
8. Columbus.
9. Walter Raleigh.
10. Washington.
11. Napoleon.

References.—*The Story of Greece*, J. A. Harris; *The Story of Rome*, Arthur Gilman; *The Story of Mediæval France*, Gustave Masson; *The Story of Early Britain*, A. J. Church; *Young Folks' History of Greece*, Yonge; *Young Folks' History of Rome*, Yonge; *Young Folks' History of France*, Yonge; *Young Folks' History of England*, Yonge; *French Historical Tales*, Morris; *English Historical Tales*, Morris; *American Historical Tales*, Morris; *Alfred the Great*, Hughes; *Walter Raleigh*, Stebbins; *Discovery of America*, Fiske; *American Explorers*, Higgins; *Stories of Discoveries*, E. E. Hale; *Life of Washington*, Scudder; *Century Magazine*, Vols. 48 and 49.

## SENIOR GRADES.

### HISTORY AND LITERATURE.

The plan of presentation here is similar to that in previous work, except that more prominence is given to questioning and gaining thoughts directly from the author. The pupils read for themselves.

The historical matter selected is supplemented by readings from the best classic authors, illustrating the period or character under discussion, and the pupils are led by questions to form conclusions in regard to the subject.

Beside the references given, many standard works are consulted.

## C SENIOR—Seventh Year—First Term.

**Topics.**

### FRENCH HISTORY.

1. Cæsar in Gaul.
2. Attilla.
3. Charlemagne. (Review of work of previous year.)
4. Joan of Arc.
5. Louis XIV.
6. Louis XVI.
7. The French Revolution.
8. Napoleon. (Review of work of previous year.)

### LITERATURE.

Readings from the following and other standard authors:

*The Snow Image and Other Tales*, Hawthorne.

*Gulliver's Travels*, Swift.

*Essays from Sketch Book*, Irving.

Also literature related to the History work.

Historical References.—*Young Folks' History of France*, Yonge; *French Historical Tales*, Morris; *Story of France*, Masson; *Cæsar's Commentaries*.

C SENIOR—Seventh Year—Second Term.

**Topics.**

GERMAN HISTORY.

1. Herman.
2. Charlemagne. (Review of work of previous terms.)
3. Luther.
4. Thirty Years' War.
5. Frederic the Great.
6. The Struggle for Freedom.
7. Bismarck.

LITERATURE.

Readings from the following and other standard authors:

*Being a Boy*, Charles Dudley Warner.

*Snow Bound*, Whittier.

*Short Poems*, Longfellow.

Also literature related to the History work.

Historical References.—*Young Folks' History of Germany*, Yonge; *German Historical Tales*, Morris.

B SENIOR—Eighth Year—First Term.

**Topics.**

ENGLISH HISTORY.

1. Cæsar in Briton.
2. Alfred the Great. (Review of work of previous term.)
3. William I.
4. Thomas à Becket.
5. Richard I. (Review of work of previous term.)
6. Magna Charta.
7. Henry VIII.
8. Elizabeth.
9. Oliver Cromwell.
10. Victoria.

LITERATURE.

Readings from the following and other standard authors:

*Boys' Towns*, Howells.

*Essays from Sketch Book*, Irving.

*Tales of the White Hills*, Hawthorne.

Also literature related to the History work.

Historical References.—*Cæsar's Commentaries; Old English History*, Freeman; *Child's History of England*, Dickens; *Young Folks' History of England*, Yonge; *English Historical Tales*, Morris.

B SENIOR—Eighth Year—Second Term.

**Topics.**

PERIOD OF DISCOVERY AND SETTLEMENT.

1. Ancient America.
2. The Vikings.
3. Explorers.
4. Puritans.

LITERATURE.

Readings from the following and other standard authors:

*Birds and Bees*, Burrows.

*Evangeline*, Longfellow.

*Robert of Sicily*, Longfellow.

Also literature related to the History work.

HISTORICAL REFERENCES.—*The Discovery of America*, Fiske; *American Explorers*, Higginson; *Stories of Discoveries*, E. E. Hale; *Life of Columbus*, Irving.

## A SENIOR—NINTH YEAR.

The history work is continued in this grade in a complete study of United States history. The text-book used is the Sheldon-Barnes United States History, upon the plan of which the work in the lower grades is largely modeled. Much original matter, in the form of letters and contemporary documents, is brought together in the book, united by a thread of narrative; the effort is to have the pupil use these as material for his own thinking, and the questions, both those of the book and of the teacher, are planned to help the pupil form his own judgments so far as he is able.

Supplementary reading is indicated in the text-book, and is an important feature of the course. Material for essay work is also largely taken from history study in this grade, and other work in English is based upon it.

### LITERATURE.

Readings from the following and other standard authors:

*Ivanhoe*, Scott.
*Hunting of the Deer*, Charles Dudley Warner.
*Vicar of Wakefield*, Goldsmith.
*Travelers from Altruria*, Howells.
*Vision of Sir Launfal*, Lowell.
*Masterpieces of American Literature* (Houghton & Mifflin).

NOTE.—All the grades are provided with libraries of choice books from standard authors, and much reading at home as well as at school is encouraged by the teachers. The constant effort is to cultivate a taste for good reading.

# DAILY PROGRAM.

| Time. | A Senior—Rooms 39 and 10. | B Senior—Room 40. | C Senior—Rooms 11 and N. Senior Hall. |
|---|---|---|---|
| 8.30 to 8.45 | OPENING E ERCISES. | | |
| 8.45 to 9.15 | Science, Monday, Tuesday, Wednesday. | Science, Monday, Tuesday, Wednesday. | Science, Monday, Tuesday, Wednesday. |
| 9.15 to 9.45 | English, Thursday, Friday. | English, Thursday, Friday. | Reading, Thursday, Friday. |
| 9.45 to 10.30 | Reading Classic Authors. | Reading Classic Authors. | Drawing, Monday, Wednesday, Friday.<br>Manual Training, Tuesday, Thursday. |
| 10.30 to 10.45 | RECESS. | | |
| 10.45 to 11.15 | Drawing, Monday, Wednesday, Friday. | Drawing, Monday, Wednesday, Friday. | Preparation in Arithmetic. |
| 11.15 to 11.45 | Manual Training, Tuesday, Thursday. | Manual Training, Tuesday, Thursday. | Recitation in Arithmetic. |
| 11.45 to 1.15 | INTERMISSION. | | |
| 1.15 to 1.45 | Geography. | Geography. | English. |
| 1.45 to 2.10 | Vocal Music, Monday, Tuesday, Wednesday.<br>Geography, Thursday, Friday. | Vocal Music, Monday, Tuesday, Wednesday.<br>Geography, Thursday, Friday. | Vocal Music, Monday, Tuesday, Wednesday.<br>English, Thursday, Friday. |
| 2.10 to 2.35 | Preparation in Arithmetic. | English History. | Preparation in Geography. |
| 2.35 to 3.00 | Recitation in Arithmetic. | Preparation in Arithmetic. | Recitation in Geography. |
| 3.00 to 3.30 | American History. | Recitation in Arithmetic. | German History. |

# DAILY PROGRAM.

| Time. | A Junior—Rooms 29 and S. Senior Hall. | B Junior—Rooms 28 and N. E. Junior Hall. | C Junior—Rooms 27, 26, Junior Hall, and N. W. Junior Hall. |
|---|---|---|---|
| 8.30 to 8.45 | | **OPENING EXERCISES.** | |
| 8.45 to 9.15 | Preparation in Arithmetic. | Literature and Reproduction. | Literature and Reproduction. |
| 9.15 to 9.40 | Recitation in Arithmetic. | | |
| 9.40 to 10.05 | Drawing, Monday, Wednesday, Friday. | Preparation in Arithmetic. | Preparation in Arithmetic. |
| 10.05 to 10.30 | Manual Training, Tuesday, Thursday. | Recitation in Arithmetic. | Recitation in Arithmetic. |
| 10.30 to 10.45 | | **RECESS.** | |
| 10.45 to 11.15 | Science and Reproduction. | Science and Reproduction. | Science and Reproduction. |
| 11.15 to 11.45 | | | |
| 11.45 to 1.15 | | **INTERMISSION.** | |
| 1.15 to 1.45 | Reading. | Drawing, Monday, Wednesday, Friday. | Reading. |
| 1.45 to 2.10 | Geography. | Manual Training, Tuesday, Thursday. | Geography. |
| 2.10 to 2.35 | Geography, Monday, Tuesday, Wednesday.<br>Vocal Music, Thursday, Friday. | Geography, Monday, Tuesday, Wednesday.<br>Vocal Music, Thursday, Friday. | Geography, Monday, Tuesday, Wednesday.<br>Vocal Music, Thursday, Friday. |
| 2.35 to 3.00 | Literature and Reproduction. | Geography. | Drawing, Monday, Wednesday, Friday. |
| 3.00 to 3.30 | | Reading. | Manual Training, Tuesday, Thursday. |

# DAILY PROGRAM.

| TIME. | A PRIMARY—Rooms 14, 15, 16. | B PRIMARY—Rooms 12 and 13. | C PRIMARY—Rooms 9, 17, and Primary Hall. |
|---|---|---|---|
| 8.30 to 8.45 | | **OPENING EXERCISES.** | |
| 8.45 to 9.05 | Nature Study and Reproduction. | Nature Study and Reproduction. | Nature Study and Reproduction. |
| 9.05 to 9.40 | | Drawing and Painting. | Drawing and Painting. |
| 9.40 to 10.05 | Vocal Music and Physical Culture. | Vocal Music and Physical Culture. | Vocal Music and Physical Culture. |
| 10.05 to 10.20 | | **RECESS.** | |
| 10.20 to 10.40 | Reading. | Reading. | Reading. |
| 10.40 to 11.00 | Formal Number Work. | Formal Number Work. | Dry, Liquid, and Long Measures. |
| 11.00 to 11.20 | Buying, Selling, Weighing Number concretely used. | Weighing—Buying and Selling and related Number Work. | Sewing in Color—Related to Nature Study. |
| 11.20 to 11.40 | Supplementary Reading—Related to Nature and Story Work. | Supplementary Reading—Related to Nature and Story Work. | Molding with Clay and Sand—Form Work related to Nature Study. |
| 11.40 to 1.15 | | **INTERMISSION.** | |
| 1.20 to 1.40<br>1.40 to 2.00 | Story and Reproduction. | Story and Reproduction. | Story and Reproduction. |
| 2.00 to 2.20 | Number Work—Long, Liquid, and Dry Measures. | Color Work—Selecting, Matching, and Mixing Colors. | Color Work—Selecting, Matching, and Mixing Colors. Form Work—Direction Exercises, Cutting and Folding. |
| 2.20 to 2.40 | Form Work—Cutting and Folding. Molding. | Form Work—Cutting, Molding. | Word Building. |

(No 7)



# NATURE STUDY

—BY—

Prof. O. P. JENKINS

FROM THE

SCHOOL REPORT

—OF—

OAKLAND, CAL.

1896-97.

# NATURE STUDY

—BY—

Prof. O. P. JENKINS

FROM THE

# SCHOOL REPORT

Of OAKLAND, CAL.

1897-98.

---



---

OAKLAND, CAL.:
R. S. KITCHENER, PRINTER
565 Thirteenth St.
1897.

*MR. I. W. McCLYMONDS,*
*City Supt. Schools, Oakland, Cal.*

I herewith submit to you an account of work done in the Oakland schools in what is termed *Nature Study*, which came under my direction, during January to May, 1897:

First, it is proper to make a brief explanation of my connection with this work. What has been variously known as Nature Study, Elementary Science or Observation Lessons has for sometime received in many of the Oakland schools, considerable attention, and in some of the schools work in these lines has been carried out very successfully.

Those teachers who were thus successful, together with a number of others who felt that such work would be of great value in the schools, and who wished some aid in its introduction, had from time to time proposed plans for receiving this aid and strengthening their work in this direction. In January, 1897 a plan was completed by which a large number of the teachers of the Grammar and Primary Grades agreed to do work in their schools in Nature Study under my direction. This movement was a voluntary one on the part of the teachers connected with it. They organized for the work, appointed an executive committee to arrange the details of business involved in the work, and voluntarily taxed themselves to pay a fair salary to a special teacher whose duties were to devote full time to the details of the work among the schools.

It is proper at this point to pay tribute to the enterprise, enthusiasm and intelligent devotion to the work of the schools, which this movement evinced on the part of the teachers. The City of Oakland is to be congratulated that the schools are in the hands of those who are so thoroughly and intelligently alive to the interests of the children. One hundred and twenty-five teachers enrolled themselves in this class.

Miss E. B. McFadden was chosen as the special teacher in the work, and to her energy and efficiency was due in a very large measure, whatever of success attended the work.

It goes without saying that all connected with the work appreciate the enthusiasm, and wise and practical aid on every hand rendered by you without which the work could not have proceeded.

## Conditions Governing the Work.

In this experiment it should be remembered that on account of the conditions at the time definite work could not be arranged for each school. Some of those conditions were as follows:

Among the teachers of the class all grades were represented. In some of the schools much work in this line had already been done, in others,

very little had been accomplished. The work was voluntary on the part of all, and had to be adapted to a program already in action, and so arranged as not to interfere with the results in other lines already planned for. One other fact should not be lost sight of, and that is the greatness of the work and the short time, and the limitations of the instruments employed.

**Plan of the Work for the Period of February to May Inclusive.**

To me fell the duty of preparing the directions, which were printed by the Department, for the preparation and study of the objects and experiments in the work. It was also my pleasure to spend one day in every two weeks visiting the schools, meeting the pupils and teachers in their rooms. Also on the afternoon of the same day I met at the High School Building all the teachers of this class for a general discussion of the work, and for a detailed description and practical illustration of the lessons which it was proposed to repeat in the schools.

A plan of visitation was arranged by Miss McFadden, by which she went from room to room of those teachers who belonged to the class. She examined the work done in Nature Study, gave lessons to the pupils, discussed the subject with the teachers, distributed material and apparatus among the rooms, and gave such other aid as seemed necessary or was possible. She also met the teachers every other week, filling in necessary details, explaining apparatus and giving directions as to the places where material might be found, and the best time for gathering it. The obstacles met with in carrying out the work were discussed. On the suggestion of the teachers she accompanied groups of them on several excursions into surrounding canyons, where material was collected, and plants and animals observed in their natural environments. She also took several classes from various schools on short trips. By these means the principles governing the work were discussed, the actual work was done in illustrations, and material and printed directions for its use were distributed.

## General Consideration.

It is considered first that at least with the lower grades the objects and experiments are to be treated simply as phenomena, not as studies in any of the formal sciences. They are to be used as lessons in accurate seeing and clear thinking in the presence of facts. It is only after knowledge and experience have sufficiently accumulated and the mind is sufficiently mature to take interest in the process, that the pupils may be induced with profit to organize these facts into sciences. It is better with these grades not to select all the lessons for a long continuous period from one group of phenomena, for example, those pertaining to a single plant, or even those connected with plants alone in general. According to the conditions of season, of time, of various causes afford-

ing opportnnity, the lessons are to be selected from plant, animal and inorganic world, not continuing for a very long time with either exclusively. Even if it is desired in the course of the school life to present those facts which will illustrate the principles of one of the sciences, say Botary for example, they may better be presented from time to time with intervals spent in the study of other phenomena. It is a mistaken notion that a child, when it begins the study of a certain thing, an animal for example, must see, think, or hear of nothing else till that is exhausted.

If a wide range of phenomena and facts concerning that part of Nature immediately around us is used, there may be built up an excellent back ground in experience, habits of accurate and independent thinking, and a fund of useful and interesting knowledge, which will serve as a most valuable equipment in any line of work afterward to be taken up. It will also give just that introduction best fitting one to begin the study of one of the formal sciences.

It has been the more usual custom in Nature Study to select the lessons from among plants or animals. Among the subjects which follow it will be seen that the inorganic world has been equally drawn upon for material. Experience will soon teach that phenomena from the physical world are as interesting to the majority of children as are those from the world of living things. They, besides, offer some advantages as lessons, in that they can be, in general, more easily isolated and thus put as more simple problems. And further, the knowledge thus gained is of fully as much practical every day use, forming as it does the basis of the explanation of so much of the physical setting of our daily life.

In making use of plants and animals the most valuable phenomena, both as educational means and as simple knowledge are those pertaining to the activity of the organisms, their ways of doing things and the adaptation of each to the conditions of its particular life. These should be the subjects of the lessons rather than simply form, color or classification; not that the latter are to be avoided altogether, but that they should not receive that attention at the sacrifice of what is of much greater value in the work in the stages here provided for.

In this brief report it is not possible to discuss at length the *method* to be used in the treatment of these subjects in the schools, nor would it be proper to do so.

One point, however, may be emphasized, and that is, that if the best results of this work are sought, the lessons should all be planned to make them as far as possible, a series of problems which are to be solved only by clear seeing and accurate thinking on the part of the pupils. This will be defeated to a very large extent if the lessons are to be simply information about things, even when well illustrated by the real objects and experiments.

I would not, however, by any means exclude information. For there

are times, many of them, in this work, when information simply is of immense value, and it would be wrong to withhold it. Any one of the lessons if properly given will prepare the pupils to best receive and make use of valuable information; information which may then and later be the basis of wider thinking.

Then again, a problem honestly attempted but still unsolved, if explained, may give the pupil the method and encouragement which will give him the desire and power to solve many another more difficult problem.

Then also, giving certain information about a thing that pupils could not find out for themselves, on the knowledge of which many simple explanations follow, may often be the best way to open up a source of problems. For example, a knowledge of the fact that the pollen grain must fertilize the ovule to produce the seed, a fact they cannot find out independently, gives us opportunity to set many solvable problems about the distribution of pollen grains.

## DIRECTIONS FOR USE.

These directions are here published in the order in which they were given out. It was not expected that all grades would make use of them, or that each teacher who did use them would follow the exact order. Many of the things could obviously be studied by all grades, if in each the teacher would select and adapt the work to the grade in hand. For example, such is the case with most of the work here given on plants and animals. It is also clear that much of it could be repeated often with profit and interest. Even with adults the recurring phenomena of the seasons with the changes in the plants and animals in adaptation to them never fail of interest.

While the work which here follows may seem "unsystematic" and to have "no logical sequence," it will be noted that in both the non-living phenomena and in the plants also which have been selected there is progression. For example, the physical phenomena will give those conceptions of the properties and composition of air and water necessary to understand them as factors accomplishing great work in nature, and in their important relations to the organic world. The occasional interruption of the continuous contemplation of these phenomena will not in any way interfere with the final organization of them into a so-called "logical order" or systematic view of the whole.

This list of directions should not be considered by any means as a course of study, but must be looked on in the relations which I have attempted above to make clear. Many of the directions cannot be made clear without diagrams, which cannot be here introduced. In the actual work with the teachers the material and apparatus were present and their use was demonstrated.

NATURE STUDY IN THE ELEMENTARY GRADES.

In the selection and treatment of the subjects of the lessons, each fact or phenomenon should be treated in the earlier grades as isolated facts. That is, they should not be thought of as parts of some of the formal sciences.

It is advisable not to start with the attempt to see the "plant as a whole," the "animal as a whole," or anything in too great a number of relations. There is a better time for this sort of work later. Every conception now gained may be made use of in future work, but what use is to be made of it need not be kept in mind during the lesson now. It is certainly best for the teacher to keep himself free to make use of all the thoughts, questions and interests which may arise in the child suggested by the object or experiment.

The object of the work is not that by the end of the term a certain number of definite facts are to be learned, but rather that a certain amount of time may be spent in seeing, thinking and enjoying.

The object may come from any source, the plant, animal, or non-living world.

As far as possible introduce lessons which will allow the putting of questions and problems to be solved by the children. Give them time for this, be in no hurry to get the answers and adopt some means to get as many individual answers as possible. Keep lists of questions which the children may ask. From these valuable suggestions may be drawn for future lessons.

The lessons may be made the subjects of written work, but obviously the time of the lessons is not sufficient for the written account. It may be made a part of the language work. Written accounts of the Nature lessons may be asked for at any time.

To make a start we will begin by planting seeds, and making some aquaria for water forms of plants and animals. Into the aquaria salamanders' and frogs' eggs will be placed. While these are growing and developing we will introduce lessons on phenomena of non-living things, beginning with heat. Following this are directions to assist in this beginning.

These are chosen as suggestions only. Any one at any time should be perfectly free to substitute for these other lessons which the time and circumstances may show to be better. Uniformity in facts is not sought for, but in the spirit, method and results as judged by the intellectual progress of the child.

As far as possible have the children do the work of planting, experimenting, taking care of aquaria, etc., etc.

## Seed Planting.

BEANS, PEAS, CORN, WHEAT, MUSTARD.

1. To arrange for plants in all stages of growth, plant in soil as follows:

Partially fill a rather shallow box with fine sandy soil. Moisten thoroughly. Sow the seeds and cover the box with a sheet of glass (the glass covering should be so arranged as to admit a very little air to prevent mold).

2. To see how the roots grow and the root hairs form, grow the seeds in water. The following arrangement is a good one:

Soak seeds over night in water. The next morning place them in a germinator. This may be made with a saucer, tumbler and a glass jar somewhat larger than the tumbler. Tie the netting over the tumbler, fill with water (A) and place in saucer (C) in which is a little water. Put the seeds on the netting and place the jar (B) over the whole. A moist chamber is thus formed, preventing the seeds from drying.

3. To watch the growth of roots in soil the following apparatus is excellent:

Place a sheet of glass about 8 x 6 inches next a sheet of zinc of the same length, but one half inch wider. Separate the glass from the zinc by narrow slips of glass. Any water proof cement may be used to keep the slips of glass in place. Fill the space between with fine soil. Support the whole on one edge, slightly inclined, the glass on the uppermost side. Plant the seeds in the soil. Keep a black cloth over the glass when the plants are not under observation.

Encourage the children to bring many forms of seeds which they may arrange for growth as they see fit.

## Aquaria.

Aquaria of any form will be found to be very useful. A number of glass fruit jars may answer. Where large glass vessels can be obtained their greater advantage will suggest their use. A few extra jars and glass tumblers ought always to be kept on hand to put things in that the children may bring, or for use in collecting. To maintain an aquarium without having the contents spoil and die, requires intelligent experimenting, which in itself may be a valuable series of lessons. Having the vessels ready the aquarium may be studied from time to time.

## Eggs of Frogs or Salamanders.

These may be obtained during the winter time. Secure some and place them in a jar of water. Put but few eggs in a single jar. Do not have the water very deep. Keep a very small amount of green algae in the jar. The development of the eggs into tadpoles, and of the tadpoles into adult animals may be watched day by day with great interest if they are kept successfully. If the eggs are obtained while in the earliest stages of development, the fact can be clearly seen with a hand lens that the little globule which coustitutes the egg is at first a smooth sphere, and then soon has a crease formed on its surface dividing it into

halves, that these again divide and so on till the divisions become so small that they can no longer be seen. Of course the full significance of this fact one would not attempt to teach here, but it is well worth seeing as a fact. Then every step of formation of body, head, limbs, tail, etc., may be noted as the process progresses.

### Insects.

Insect's eggs and cocoons as they may be found can be placed in bottles and jars with netting tied over them to retain the hatched out insect when it appears. Date these and examine from time to time to detect time and progress of development.

It is well to have some one, or a small group of children to take charge of and care for all such jars, etc.

## Lessons with Non-living Objects.

#### HEAT EXPANDS WATER.

Fill a flask or a bottle with water. Close with a cork through which a glass tube passes. A short tube will answer, but if two or three feet long it will be better.

To start with, have sufficient water in the flask to extend up into the tube two or three inches. Be sure to have no air in with the water. Allow members of the class to fill and arrange the apparatus. Let all see clearly just how everything is arranged.

Place the flask on the stove, or over an alcohol lamp, and have the class observe the result, and, if they can do so, explain why the water rises. If the simple explanation that the heat makes the water larger (expands it), is not given, do not give it but allow them more time to think on the matter. If wrong explanations are offered, do not immediately neglect them but ask for proofs, or devise experiments which disprove the offered explanation. For example, if a child insists that the water rises in the tube "because heated water is lighter and goes up," place the apparatus so that it extends in a horizontal position and repeat the experiment.

The above may occupy the time of more than one lesson. It ought not to be hurriedly passed over. In subsequent lessons it may be proposed to experiment with other liquids. Allow the children to select the liquids, arrange the apparatus, and try the experiments as far as possible. The effect of cold may be studied also.

When a few liquids are thus experimented with and comparisons made between them, the thermometer may be introduced. It is to be seen as a small flask filled with mercury, or with colored alcohol.

A number of simple experiments can be devised with the thermometer, which will make clear its use in determining the temperature of things.

In all experiments give as much chance as possible for each one to

express his individual opinion, and to ask his own question. Do not by your conduct with the class put a premium so much on any kind of answers, even bright ones, as on *earnest* questions and answers. Give all such, even if apparently ignorant and far from right, every consideration. Children, like older people, are sensitive in regard to the respect given to their opinions. Nothing to them is so inimical to the independent formation of opinion as to have their opinions treated with disrespect. If one is wrong, prove that he is wrong, but neither ridicule nor ride over him. Avoid allowing a few to lead the class and set opinions for the rest.

### HEAT EXPANDS AIR.

Use the flask and tube of the experiment of heat expanding water. Have the flask clean and dry. Place the end of the tube under water. Warm the flask with flame of the lamp. As the bubbles of air escape, have the children observe what happens and explain. Cool the flask. Repeat the experiment several times; or better, allow the children to repeat it.

See how sensitive the air is to even a small amount of heat. Arrange flask and tube so that the mouth of the tube is covered with water, having driven out enough air so that the water will rise well up in the tube. Place the hand or just one or two fingers on the flask and observe the change of volume.

Arrange the flask and tube in a horizontal position. Get a little water in about the middle of the tube. It is better to have it colored with ink or some other coloring matter; this will enable its motion to be more plainly seen. Repeat the experiments with this apparatus. It will be very sensitive to small amounts of heat.

In addition to these experiments, which are to be examined very closely and seen clearly till they are well understood, many other illustrations of the fact that heat expands air may be devised by both the pupils and yourself. For example, a football or a bladder partly blown up, then heated, fills out by the expansion of the contained air.

The flask and tube with a paper scale may be used as a thermometer. For this purpose support the flask so that it stands perpendicularly with the mouth of the tube immersed in water, with the water rising a little way up in the tube; or support the whole in a horizontal position, putting a drop of liquid in the tube. In the latter case a drop of water cannot be used, as it will evaporate. Use a small tube and a drop of strong sulphuric acid or a drop of mercury.

What makes the best thermometer of the substances thus far used? Why? Give time for discussion and comparative experiments.

As it is desirious, among other things, to use the knowledge of the effects of heat on air to understand currents of air, winds, etc., it might be well to next attack the subject of why heated air rises. Children have generally learned the statement that "heated air rises," but can

give no further explanation than that it rises "because it is heated." The fact that heated air "goes down" in some cases may be referred to.

(The general subject of why things float when immersed in liquids or gases heavier than they are may be taken up.)

HEAT EXPANDS SOLIDS.

The question may now be asked of the pupils: Does heat expand solids? They will be ready to say that they think that it does, and now comes the opportunity of having them devise a means of proving it. If, unaided, anyone of the class can invent such apparatus the results will be excellent. The following are some simple forms of apparatus used to illustrate expansion of solids. A metal ball just passing through a metal ring at the ordinary temperature of the room, will not pass when heated, and will pass more readily when the ring is heated. An iron or other metal bolt nicely fitting into a hole in another piece of metal may be used in the same way. A simple apparatus can be made which will show expansion in rods of various metals, or of various forms such as poker, stove lid, gas pipe, etc. Two heavy blocks of wood are used to support the object. On one side of one block is nailed a strip projecting above the top of the block. One end of the object (iron poker for example) is supported by this block, the end of the poker being pushed firmly against the projecting strip, the other end of the poker is supported by the other block, the end projecting beyond the block. When the poker is heated the strip prevents the expanding poker from pushing in that direction, thus the whole of the movement is shown at the free end. As the expansion is very small, it may be made conspicuous by use of an indicator, made as follows: On a small upright support high enough to stand just behind the free end of the poker, place a card with degrees of a circle marked on it. At the center of the circle fasten a pin or small nail on which turns as a pivot a slender strip of wood as a lever. If the short end of the lever is placed against the end of the poker when it expands the long end as a pointer passes over the graduated circle, giving a magnified view of the expansion. If one end of the lever is very short, and the other long, a small amount of expansion may be detected. On this simple apparatus many objects may be tested. The heating may be accomplished by alcohol lamps, or a row of candles.

If two strips of different metals are riveted together, and heated the unequal expansion of the metals will cause the double strip to bend. Iron and copper are good selections.

Illustrations of effects of expansion of solids may be found if pupils are set to looking out for them.

## The Fern.

Though the fern is one of the most common of our house-plants, yet its life history is not generally known. There are two stages in its life,

these stages being generally known as generations. The first stage or generation is the small, flat, heart-shaped plant called the prothallium. The second stage is the fern as we know it. The spores are found in numerous groups on the back of the leaves. Each one of these groups is in turn made up of smaller groups which contain the spores. These smaller groups are called sporangia.

The spores may be collected by placing the spore-bearing leaves on sheets of paper, and letting them dry, when the spores will be discharged, covering the paper as a fine, brown powder. If these are sown on fine, rather closely-packed earth, and kept moist, and covered with glass so as to prevent evaporation, within a week or two, or longer, a fine green moss-like growth will make its appearance, and by the end five or six weeks, the little flat, heart-shaped plants spoken of before as the first stage appear. They are of a dark green color, and are called prothallia. These prothallia are attached to the ground by fine root-hairs. Very soon we may find growing from the under side of some of the larger of these little plants, the fern as we know it. It is attached to the ground as well as to the prothallium. As the plant grows, the prothallinm dies, leaving the fern as an independent plant, which afterwards bears the spores.

NOTE.—The children will not be able to make out the reproductive parts, and it is not necessary for them to do so. They are found on the under side of the prothallium, and correspond to the staminate and pistillate parts of flowering plants, but are very different in form. (The archegonia or pistillate parts are just behind the notch, the staminate parts just back of these. The spermatazoids, which represent the reproductive part of the pollen grains of the flowering plants, are motile and by means of the dew or rain swim to the archegonial cell, which, after fertilization by one of them produces the fern. The fertilized cell, grows directly into the fern, unlike the ovule of the higher plants, which first produces the seed.

The children, although they need not know about archegonia, etc., will be able to find the groups of spores on the backs of the leaves, their different methods or arrangement and protection in the various kinds ot ferns.

## Evaporation, Condensation of Vapors, Solution.

The phenomena of evaporation, condensation of vapors, and of solution, are interesting facts in themselves, and may be made the subjects of many lessons. In addition to the interest the facts possess, knowledge of them allows a better understanding of a number of processes in the life of a plant or an animal, also in the formation of fog, dew, clouds and rain.

### EVAPORATION OF LIQUIDS.

A few drops each of different liquids may be placed on a clean sheet oi glass, such as glycerine, water, gasoline, alcohol, and ether or chloroform

Attention is directed to what becomes of them. Certain ones disappear quickly, others remain longer, or may be on the glass several days.

Small vessels with glycerine, water, and alcohol may be kept open, and results looked for. To show that when a substance disappears that it is still in existence, place a few drops of ether, alcohol, chloroform, or gasoline in the bottom of a tumbler. Cover with a glass or card. When all the liquid has disappeared, have the glass examined, then carefully with a match, or better, a long splinter, light the contents, when it will burn. Use only small vessels, as these vapors make explosive mixtures with air. In these small quantities, with wide-mouthed vessels, such as tumblers, there is no danger. For obvious reasons, a light should not be brought near open vessels containing these substances. In each kind of liquid used, show that where evaporation takes place, heat is used up. Do this by moistening the bulb of a thermometer with the liquid, and seeing the mercury fall more rapidly, the faster the evaporation. With ether a degree below freezing may be reached. Use cotton saturated with the liquid on the bulb of the thermometer.

### OF SOLIDS.

To show that a solid may evaporate: Place some gum camphor in a corked jar that has been wiped clean. In a few days crystals of camphor will be found on the upper parts of the jar.

If a small bit of camphor be heated in the bottom of a test-tube, it first melts, then passes into vapor, which soon forms into crystals on the sides of the upper part of the tube.

A solid crystal of iodine heated in the bottom of a test-tube passes into a beautifully-colored vapor; this forms into crystals on the upper part of the tube. This experiment is excellent in showing a solid passing immediately into a vapor, in giving a vapor which can be seen; and in giving a vapor that is heavier than air.

Of course other substances may be chosen rather than the ones mentioned above, and the greater the number, the better. All of the above are inexpensive as but very small amounts are needed and only very small amounts should be used. It is a good rule to follow in experimenting with substances to use only small amounts. In such a case the experiment will be more likely to succeed and will be more neatly done.

### THE PHENOMENA OF BOILING WATER.

For the observation of the phenomena, a glass flask which will allow its contents to be seen, should be secured. Let each step be noted; the currents formed in the heated water, just how they go; the formation of the bubbles of air, which is simply the expanding of air dissolved in the water (not steam); finally, the formation of bubbles of steam. These form on the bottom of the vessel, just over the heating flame. The first steam-bubbles do not reach the surface, since they condense on

reaching the cooler water. When the water gets thoroughly heated, the bubbles of steam reach the surface, and finally pass out of the mouth of the flask. There they are partially condensed into a cloud or fog, which can be seen.

There are many points of difficulty in this with the children, from former notions picked up here and there. It is hard to understand that the steam is invisible, as are many of the vapors in the preceding lessons (of gasoline, ether, etc.). But these very difficulties give opportunity for questions. which they may discuss with each other, for the settling of which they may devise experiments. Do not be in too great a hurry to have it all taught. We may remember that what we wish of our material is, that it may give just those questions which it is possible for the children to work on. We should give them a chance to work at these questions when we find them. For those pupils who are ready for it, the thermometer may be used, and the gradual rise of temperature observed until the water boils, when it will be seen that it stands at 212° Fahrenheit, whether in the boiling water, or the steam just above it (not in the fog formed outside). Alcohol may be used to show that other liquids have a lower boiling point.

### CONDENSATION.

The phenomena of condensation will constantly come up in the foregoing experiments, and is then, of course, to be noted. This is especially so with camphor, iodine, and water. Many experiments may be devised to further illustrate the results of evaporation and condensation of water. It must be seen that such high degrees of heat as for boiling is not needed for evaporation.

A glass vessel, partly filled with water, and the mouth closed, will show water constantly on its inner surface, coming from the condensed vapor arising from the water.

The condensation of water on the cold surface of a plate of glass, exposed to the breath, or to the surface of the skin, or the under surface of a leaf, or over the flame of a lamp or candle, will show that there is vapor of water coming from all these sources.

Water may be distilled from a flask, by connecting it by a tube to another vessel. The water boiled in the flask will pass as steam into the tube, which is kept cool by moistening it. From the tube the water drops into a receiving vessel.

It may be said, in passing, that it is now taught that in the formation of fog and clouds, each particle of water of the fog or cloud has condensed upon a particle of dust in the air, and if there were no particles of dust there could be no fog, clouds, or rain. By "dust" is meant any small object floating in the air, such as go to make up what we commonly speak of as dust and smoke.

The application and illustration of the above lessons will occur to each one.

SOLUTION.

Use for lessons in solution several common substances: some which dissolve readily in water, as sugar and salt; some which do not dissolve so readily, as camphor, or potassium bichromate; and some that do not dissolve perceptibly, as whiting. Use among them some which give a colored solution, such as sulphate of copper, bichromate of potash, or some of the aniline dyes. Have the appearance of the solution carefully noted and compared with the mixtures with water when no solution takes place.

Allow them to evaporate a solution of sugar or salt until the sugar or salt is regained. This may be done in a tin cup, on the stove. If the evaporation is allowed to proceed slowly, beautiful crystals may be formed. A solution of alum in an open jar, left in the school-room in a place where it will not be disturbed, will give beautiful crystals. If strings are suspended in the jar, the crystals will form on the strings, and can then be removed.

If you have a friend among the druggists, he will no doubt arrange you some sort of solution giving beautiful crystals. There are a number of ways you may devise to show the formation of crystals.

Another method of making a pretty experiment is to smear a sheet of glass with a solution of some salt, and as the water dries out, the salt shoots across it in beautiful crystals. Sal ammoniac, sulphate of copper, and common salt will answer. If this process is watched with a microscope it is most interesting. For the older pupils, the forms of crystals make an interesting study, and some lessons may be prepared on this later.

That things dissolved can pass through filters, and those not dissolved cannot pass through, can of course be shown by the use of funnel and filter paper. This conception of dissolved substances is important in the later lessons on how certain foods get into the animal and plant bodies.

## Mushrooms.

At this time of year, a great number of interesting forms may be found in all sorts of places, and brought in by the children.

One of the umbrella forms may be used for the first lesson. The following names of the parts will be convenient: *cap*, *stalk*, *plates* or *gills*, and the *ring* may be given.

Show where the spores are formed. The spores are the things which answer for its seeds. They are microscopic, and hence cannot be seen by the children. Cut off the cap, place it gill-side down on a sheet of glass. In a few hours, or by the next day the glass will be covered by a dust which comes from the surface of the gills. This dust consists of the spores. They may be seen better if the glass is placed over white or dark paper, according as the color of the spores may be dark or light.

These spores grow in suitable places, into a fine network of threads like cotton or mould, extending into rotton wood, or decaying vegetable matter. (These the children will not be able to make out, but may be told about them.) Then when the proper time comes, they send up the part we see above the wood or ground. Have the children see the stages of growth of this part.

Having seen how the spores are borne on the gills of the kind above described, have the children find where they are borne in other forms: e. g., puff ball; the kinds that discharge spores through little tubes; the kinds that carry them on the outer surface—plane, on spines, prickles or warts; the kinds that are composed of a gelatinous substance with the spores on the surface.

One kind of puff ball, the earth star (Geaster) has a star-shaped collar which will spread out when wet, and fold up when dry. It may be well to have an earth star change its form repeatedly in the school-room. How does it do this? Why?

Get as many forms as possible. Never mind the names. Have the situations in which they grow carefully observed. These are excellent objects for drawings and descriptions.

References for the teacher:

Cooke, M. C., Fungi, (International Scientific Series) pages, 17-26.

Bennet and Murray, Cryptogamic Botany, pages 388-399.

Bessey, Botany, pages 175-180.

St. Nicholas, vol. xxii, June, 1895.

Campbell, D. H., Structural and Systematic Botany, p. 81.

## Moulds.

Having become familiar with mushrooms and their production of spores, a few of the common moulds might be observed.

An easy and almost certain method of obtaining a large form (Mucor) is by keeping a piece of bread in a closed, moist place, *e. g.* under a bell jar or in a closed glass fruit jar. The vessel is closed to prevent evaporation. In a day or so, the slice of bread becomes covered over with a felt of cotton-like threads. This can be observed to increase in quantity in a few hours. After a time some threads grow up from the general mass, and their tops form into little round knobs; the knobs later become black. If a black knob is placed under a microscope, it will be found that it produces immense numbers of spores, like the spores of the mushrooms. After this mould has pretty nearly run its course, the bread will be covered with a quantity of dark colored dust which consists of the spores. The children may be told that for the mushrooms, a similar mass of white threads grows through the ground, rotten log, or other substance, before it pushes up the mushroom part to form and distribute the spores. This white thread part is called the mycelium.

There are many other moulds which may now be used. On the same

piece of bread used to get the Mucor after that mould has run its course, other moulds will follow. Some of these are of bright colors—orange, yellow, green. These all bear spores on some kind of minute stalks. Being much smaller than Mucor, these may not be seen except with the microscope. The children may bring moulds from many other sources.

### Lichens.

In these we have still another very common group of plants. They are the plants which often form drab or grey-colored patches on the bark of trees or on the surface of stones. There are many forms—some make fringes and fuzzy coverings on fence boards or on trunks and limbs of trees. One strange form is the so-called "hanging moss," which grows so abundantly in California, hanging in long festoons from the oaks. The lichens are a group of the fungi. They reproduce by means of spores, borne oftentimes in colored cup-shaped surfaces. The spore surfaces are sometimes carried up on stalks, thus being elevated above the plant body. In some forms small portions of the plant-body become detached. These will grow into a new plant.

Their method of attachment to bark or stone, method of growth, and method of bearing the spores may be seen. For older classes, with the use of the microscope, the wonderful bit of natural history shown in the relation between the lichens and the bit of green algae on which they are parasites may be made out.

### Mosses.

Mosses are more common than ferns and little understood, except by botanists. They may be the subjects of many interesting lessons. Many of the facts about them which are of a great interest from a scientific point of view are difficult to make out and would better not be attempted in this course. Teachers who wish to learn of them are referred to the works on Botany especially in regard to the reproductive parts. The following account is only meant to bring out parts which can easily be observed.

There are a great number of forms which would be puzzling to those who are not botanists. Common forms may be found growing in moist places on the ground or on the sides or limbs of trees. These plants consist of small stems clothed with minute green leaves. The stems are fastened to the ground by means of a thick felt of hair-like threads. The whole plant is a beautiful and interesting object seen under the simple microscope. A simple leaf under higher powers shows a thin plate consisting of a single layer of plant cells. The green grains in the cells are chlorophyll bodies. These are the same in all green leaves.

Those pupils who are ready for it may be taught that it is by means of these bodies that the plant is able to make such substances as starch out of carbonic acid and water, the two great food substances of the plant,

It would do no violence to any correct pedagogical principle to tell any one who can see the green grains that by means of them in sunlight, the plant makes starch out of carbonic acid and water. As it is in mosses, so it is in all plants. If this subject is not brought up here, when it is taken up, the moss leaf is one of the most convenient in which to see the chlorophyll well.

The moss reproduces by means of spores. These in many common forms are contained in a little vessel on the top of a slender stalk which raises it up above the general bed of moss.

The spores sown in moist places first grow into minute green threads (protonema). These, in time, bear minute buds which develop into the moss plants as we generally see them.

The children may find different forms of mosses; find their spore-bearing parts; the protonemal stage passing into the adult plant. Flower pots in which other plants are growing, if kept moist, often have all of these stages.

Note to the teachers:—For yourself, you will find it a matter of great interest to learn how the spores are formed, although the subject presents considerable difficulty in making it clear to young children. Reference is made to the formation of the male and female plants, the fertilization of the oospore by the antherozoids, and the development of the sporogonium.

See Campbell, D. H., Structural and Systematic Botany, Ginn & Co., 1890, p. 93. Vines, S. H., A Student's Text Book of Botany, 2 volumes MacMillan & Co., 1894, p. 324.

## Motion or Locomotion.

There is no benefit derived from the study of muscles and bones if they cannot be seen as parts of a real motor mechanism. This can best be seen by an actual observation of the parts, and a comparative observation of several animals with markedly different styles of movements. The following animals observed carefully in their movements in walking, running, flying, jumping and swimming, will give an intelligent interest in the study of the motor mechanism of the human body.

### FISH IN AN AQUARIUM.

Movements of fins. What does each accomplish? Which propels forward? By what movements does it move backward? By what movements does it rise? Turn to the right or left? Observe movements of mouth and eyes.

### OTHER ANIMALS.

The study of the movements of a salamander will follow that of the fish. Have pupils observe carefully the position of the limbs, and exact use of them on the table; its motions in the water, and how it accomplishes them.

Since the limbs of the frog are so much better developed, and its

movements consequently so much better executed, this animal makes an excellent next step in the series. It may be studied in the same manner as the salamander. Compare the two and see what in one allows it to be so superior to the other in its movements.

In the same way, study the motions of a lizard, a dog, a cat, a horse, cow and man. Observe the motion of a bird in flying. A pigeon is most easily obtained. Gulls may be watched as one crosses on the ferries.

Of the invertebrates, observe as many as can be obtained; for example, insects—beetle, grasshopper, butterfly, etc.; a slug or snail.

Motions in general well observed, the class will be interested in seeing the mechanism of motion. The leg of a frog, chicken or rabbit is each excellent, but of course that of any small animal will answer. Any objections to dissecting an animal will not apply, or be raised by bringing a leg only of one of these animals to class.

Directions for examining the specimen: Slit the skin along the leg, lay it back, but do not remove it. It should be seen just how the skin fits to the leg; and besides, the specimen keeps in better condition if the skin can be laid back over it when the specimen is not being used. Separate carefully, without cutting any of them, or detaching them from their connections, all the parts of the leg, muscles, tendons, nerves and bloodvessels.

Have the pupils see well the muscles, and their tendons, and how they are attached to the bones. Pull on each muscle to see its action and how it is accomplished. Have them see the nerves and how they run into the muscles; the same with the bloodvessels.

After these have been clearly made out by each member of the class, have the muscles removed to see better the bones and the exact manner in which they are held together. Then take apart a joint and see its ligaments, the cartilage-capping of the bones, and the exact way in which they fit and act upon one another. The facts of the structure of a joint may be further pursued with larger joints of beef, sheep, or pigs, obtained in the meat market.

The foregoing may be made the subjects of many lessons. What has been suggested may be much extended according to time and circumstances. For example, a general view of the whole muscular system may be made by examination of the other parts of the animal.

### The Skeleton.

Next the study of the skeleton may be taken up. The bones will by this time be seen in their true light as *levers* for motion and points of attachment from which muscles make their pulls; also as solid places on which other bones rest in their action as levers—that is, as *fulcrums*. The work may now be with skeletons of representative vertebrates, and with levers and their properties.

If possible, get the pupils (some of them will have the interest and patience to do so) to prepare for the use of the class, the skeleton of a fish, salamander, frog, bird and mammal (rabbit, cat or dog). Even if these skeletons are not mounted, but in separate pieces, they can be made use of with great advantage. Let each skeleton be considered in relation to the kind of motion that each animal has.

The bones of a dog or cat are very much the same in every form as those of the human skeleton, and have the same names. Have the pupils see how the bones compare in the series, say the humerus, femur, or phalanges in all. In each case see how it is adapted to the use of the animal.

A study of the lever in its different forms, the first, second and third class, as they are known, may be made with a ruler.

A convenient piece of apparatus for study of the different classes of levers may be constructed as follows: A support for the lever consists of a stand with a wooden base about 18 by 8 inches. From the center arises an upright piece 12 inches high, 1½ by 2 inches. In the top of this is a slit to receive a rod of wood which is to act as the different forms of levers. The rod is a little more than two feet long. It works on a nail as a pivot, which passes through the prongs of the slit and the center of the rod, the one half balancing the other. It has 12 holes, one inch apart, on each side of the center. Some wire hooks can be placed in the holes and used to support weights. Now with these weights and by pulling up on the hooks, all forms of the lever may be studied. A spring balance may be used to pull up with. The different distances necessary for weights to be supported by different powers, and in what direction, may be seen.

After studying levers, find application in different kinds of tools and implements, the loss and gain of power, weight and velocity in each case. Then question about each of the bones to ascertain the case with each.

## The Pine Tree.

Just at this time of the year the pine trees about the city may be observed with interest. The growing branches, the main axis of each, the terminal bud and the small side branches containing the young needle leaves may be made objects of observation. The branches which become flowers may be noted. The one kind furnishes an immense amount of pollen, the other constitutes the young cones. In the one see just how the pollen grain is borne; in the other, just where the ovules are located, that is just at the base of the scales making up the cone. In the older cones, find the seeds. These have developed from the fertilized ovules. The ovules must receive the pollen grains before they can develop into seeds. How does the pollen reach them? The settling of this question will bring out the advantage in producing such immense

quantities of pollen. It insures that the chance currents of wind will carry the pollen to the young cones.

The microscope will show the interesting form of the pollen grains, and how, by a sort of minute wings, they are better carried by the wind. The yellow dust on the sidewalks or on little pools after a wind-storm at this time of the year is pine pollen. The microscope will determine this.

Having seen how the pollen-producing flowers (staminate) and the cones (pistilate) of the pines are arranged, the same organs in the redwoods, cypress, firs, cedars, and whatever cone-bearing plants which may be in the city may be observed. The plants are essentially the same, although the size and shape of the cones differ greatly. This, of course, gives an excellent opportunity for an exercise in making comparisons and drawing conclusions.

## Pond Life.

(With microscope.)

A number of papers will appear from time to time under this head, concerning various forms of life found in ponds and ditches; these forms may be transferred to the aquaria of the schoolroom for observation. There is no end to the list of these forms, both animal and plant. Some are only seen to an advantage with the microscope, others are large enough to be seen with the naked eye. The eggs of frogs, toads, salamanders and mosquitoes belong to this number.

### THE GREEN SCUM OF PONDS.

This consists chiefly of a number of beautiful microscopic plants. The mass of it gathered one day may be made up of one group; on another day it may consist of an entirely different group. Consequently it would be impossible to anticipate and describe what might appear. It is a good lesson if it goes no farther than having pupils find out that the green scums consist of definite forms of plants, and having them associate with these forms, many animals.

Have some one bring in a portion of such scum. Place it in a vessel of water, giving it plenty of room to spread out well. Take up a very small portion (too great a portion will give confusion only) and mount it in water on the glass slip with a cover glass. Allow the children to see it well and make out some of the forms. There will be great interest on the part of the children, but at first very wrong conceptions of what is seen.

One form of plant is very likely to occur. It consists of a single, long unbranched thread. Within it are green spiral bands of chlorophyll. The partitions across the plant are the ends of plant cells. The plant consists of a single row of cells. Those who are acquainted with Botany will recognize the plant as spirogyra, of which there are at least forty

species in the United States. Of course the children will demand names for the numerous things which they may chance to see, but few Botanists or Zoologists could give them all. A frequent examination of pond scum from different sources will allow the children to become familiar with some of the most common forms which will repeatedly occur. The names of many of these may be ascertained and supplied in time.

### DIATOMS.

Diatoms are almost always present in the above described preparations. They are small objects, generally brownish in color, often tapering at each end like a canoe. They move across the field like small boats. There are many other shapes than these among the diatoms. These are plants having delicate shells of silica. When the plant dies, the shell drops to the bottom of the pond. In certain positions, ponds or lakes, which have been the homes of diatoms for ages, have a deposit of fine mud at the bottom made up largely of diatom shells. In ancient geological times there were thus formed in some places in California and in other countries, deposits making thick strata of rock composed almost wholly of diatom shells.

If in the first lesson neither spirogyra nor diatoms are in the material observed, equally interesting forms will be seen, some of which will be described later.

## Mosquito Eggs.

The eggs of the mosquito are laid on the surface of the water of ponds, ditches and the like. They may often be found floating in watering-troughs. They form a small, black mass, which, when not closely examined, might be taken for specks of soot. These little floats consist of long, slender eggs adhering closely. Each egg is made up of a case pointed above and opening by a cap below, the egg proper being within. As the larva of the mosquito hatches out, the cap drops down and the larva, the "wriggler" or the "wiggle-tail," as the children know it, comes out and swims away.

If a few floats of eggs can be obtained some can be used for examining the eggs with the lower power of the microscope; the remainder may be placed in a small vessel of water, and the tranformation observed. The larvæ when first hatched are very small and almost transparent. At this time they make most interesting objects under the microscope. The beating of the long vessel, which serves as a heart, may be seen; also the internal tubes (trachæ) which allow the air to penetrate the body. These are connected with the breathing tube, which is a sort of spur from the posterior end of the body of the larva. When at rest and not disturbed, the "wriggler" comes near the top of the water, and extends its breathing tube to the surface, allowing its head to hang down. At the end of the tube are a number of plates which

untold, and lying on the surface of the water hold the larva in place. The air enters through this tube and extends through the system of tubes to all parts of the body.

The larva, after growing considerably, is transformed into a stage quite different in appearance. The head and thorax are very large. Now, instead of one breathing tube at the posterior end of the body, it has two extending from its thorax. This stage is called the pupa. After a few days, the skin of the pupa bursts, and the perfect mosquito comes out. For a while it may float about on the discarded skin of the pupa. It then flies away.

The mosquito is an interesting object for those who have microscopes. The piercing apparatus, the antennæ, the legs, and wings are all easily observed with low powers.

The children may easily make out the transformations, see the larvæ feed, and observe their habits. They may be kept in a glass of water in which is placed a dead leaf or two, oak or maple. For references see:

Comstock—A manual for the Study of Insects. p. 437.

Burnet M—School Zoology. p. 95.

Packard—Zoology. 357.

Comstock—Insect Life. p. 131.

### Pressure of Air, Liquids, Etc.

The previous lessons on air and water will have brought out questions requiring some knowledge of the pressure they exert, and the consequent phenomena. It is perhaps better to begin with water. Bodies floating in water may be taken as a starting point. Why do they float? Why do some float more above the water than others, while others sink? What is the effect of the same floating bodies in liquids of different densities, *e. g.*, lighter or heavier liquids.

These questions may be made the guide to a series of experimental lessons with grades above the fourth.

The last of the above questions is a good one to begin with. For the lesson there will be necessary: A small wooden rod one-half inch or less in diameter and about five inches in length; some small nails and a piece of copper wire for weighting one end of the rod; two fruit jars, one filled with water, the other with a strong solution of salt; some small blocks of wood; and some corks. The lesson may begin with the question of how the things will float in two liquids, water and salt solution. If the pupils can be led to invent an apparatus to test the difference, so much the better.

This may be done by first trying the blocks of wood or the corks. It will soon appear that they, from their awkward shapes and instability in the water, can not give good results. Then some one will be sure to suggest a method good enough. Most likely the rod of wood loaded at one end will be invented by the class. If not it may now be brought out

and will be appreciated. It is best not to have the rod loaded ready for the experiment, but reserve for the class the loading the rod just right to make it float upright in the two liquids, and marking the scale on it. With this now ready have them test the liquids. They find that the rod floats higher in the heavier liquid. Now make mixtures of the water and salt solution, and have them predict how the rod will stand, then verify the prediction.

Now other liquids may be tested and compared with water; such as milk, kerosene, or a solution of salts other than table salt.

The apparatus may be varied by preparing other forms of floats, *e. g.*, a long, narrow test tube with sand, shot or nails in the bottom to act as ballast. In the tube may be placed a paper scale. If a lactometer or alcoholometer, or other form of hydrometer (see physics), can be borrowed to show, and can be made use of, the value of the lesson will be greater. But they will see that none of them are anything more than their wooden rod with a scale.

An egg will float in strong brine and sink in water, and thus is used as a hydrometer. These experiments extended, bring the phenomena of floating clearly before the pupils.

Next the question of what makes the bodies float may be taken up. At the start do not tell them that it is "the weight of the water displaced." This is misleading and once given seems to become a sort of cant phrase in which it is hard to put the real meaning. Later this truth may be seen and verified. While the whole mathematical explanation can not be gone into, the simple fact that floating is due to the *upward* pressure of the water may be clearly seen.

Show them that when a body is placed in the water that the water presses against the whole surface. A bucket pushed down would show the pressure if holes were bored in the bottom and sides. A rubber boot placed in a bucket shows the pressure by the collapsing of the sides. A bottle filled with air thrust mouth down will show that the air is pressed upon by the water. In a floating body the pressure against the sides takes no part in holding the body up, but only the upward pressure does so.

The children will readily see that the pressure of a liquid is due to its weight, and consequently is greater in the heavier liquids. It will be very interesting to show a very light liquid like gasoline (do not use it near a light) and the heavy mercury.

From liquids it is easy to pass to air. In previous lessons air has been shown to be "something," and consequently has weight and exerts pressure. Let the children devise means of showing this to be true.

Put experiments like this in the form of questions: A glass of water evenly full is covered with a piece of paper, and then suddenly inverted, the paper being held on by the palm of the hand. When the hand is removed the water will be kept in the glass by the pressure of the air.

"Sucking" water up a tube is removing a part of the pressure of the air above the water in the tube. The pressure of the air on the water outside of the tube pushes the water up the tube.

Enlarging the chest in respiration makes a larger space. The pressure of the outside air crowds in and inflates the lungs to fill that space.

The toy called a "sucker"—a leather disc with a string in the centre illustrates this further; the pump and the siphon also.

From pressure of air, we may pass to experiments on bodies floating in the air as balloons—toy balloons, either paper filled with hot air or rubber filled with a gas lighter than air. Next we may take up currents in the air and water.

It has been seen that heat expands water and air. These are then lighter. The warm water rises in the cold, the warm air in the cooler. We have then the basis for the study of ventilation and winds.

## Flowering Plants.

The seeds that were planted have now become plants of considerable size and demand further consideration. The following questions may be taken up: What is their food and how do they obtain it? How do they form their seeds? How do they distribute their seeds? Pursuing any of these lines will raise a hundred questions pertaining to the contrivances by which each kind of plant, through leaf, stem, branch and roots, and the various parts of each, is adapted to its particular kind of life. Studying a plant from these points of view will not reqnire learning the names of the parts of the plant except where there is occasion to use the name, and also the learning of the technical names of the forms of leaf, stem and root, which are used very rarely except in technical descriptions in Systematic Botany. Although these have in the past formed a prominent part in the conventional courses in Botany, they should have little or no part in Nature Study by children.

## The Plant's Food.

This consists mainly of (1) *carbonic acid*, obtained from the air, and (2) *water*, obtained from the ground, also (3) a small amount of various substances dissolved from the soil by the water.

To show that plants take up water by means of roots and root-hairs, dig up a plant and carefully wash the dirt from the roots, harming the root and root-hairs as little as possible. Place the root in a bottle or flask, allowing the stem to pass through a cork. The cork is slit and placed around the stem. Through the cork also extends one end of a glass tube bent in such a way as to form a gauge. The tube is filled with water. (This arrangement will be shown in the lecture room.) Very soon the water descends in the tube and continues to do so rapidly, showing that the plant is using up the water. The cork ought to be covered with paraffine so that evaporation from that source can not take place.

This apparatus may be balanced on a pair of scales, or a pot with a growing plant in it may be thus balanced, and it will soon show loss of weight. (A simple and effective pair of scales may be made by the children of a rod of wood eighteen inches long, strings and two pieces of board six inches square.) To show that the water escapes from the plant by the leaves, allow the leaves to rest on the polished surface of a cold piece of glass or steel.

If this plant, or a plant in a pot is inclosed by a bell-jar or glass shade, the water coming from the plant will be condensed on the sides of the glass.

To trace the course of the water absorbed by the roots, place a solution of some analine dye in the water (eosin is good.) The coloring can be traced in the stem, if translucent, and through the veins of the leaves after some hours or a day.

These experiments may well be followed by an examination of the epidermis of a leaf with the microscope to see the stomata, the openings through which the water passes. By tearing the leaf crossways portions of the thin transparent skin which covers the leaf can be obtained, mounted in water, and the outlines of the epidermal cells may be seen. Notice also the curved cells bordering and making the stomata.

Through these not only does the water go out, but the oxygen sometimes passes out and the carbonic acid passes in (sometimes oxygen comes in). Now it is seen that through the root-hairs on the roots and stomata on the leaves, the foods of the plant come in. The veins of the leaf, and the parts of the interior of the stem and root, carry these up and down. This will be taken up later.

That the water can dissolve something from the soil may be shown by soaking some soil in rain water or distilled water, then filtering this out and evaporating the water that comes through the filter. A small amount of substance will remain. This was dissolved in the water.

NOTE.—Some of these experiments, or similar ones, and others may be read in greater detail in an excellent little book, The Food of Plants, by Laurie—Macmillan & Co., publishers.

### Currents in Water.

In observing boiling water, the upward currents from the lamp-flame and the descending currents down the sides of the flask were noticed. These may again be more carefully studied. Differently shaped vessels will show the currents in different conditions. The course of the currents will be seen better if a small amount of fine dust of crayon or sawdust is sprinkled in the water. If a few very small particles of an analine dye be placed on the surface of a flask or jar of water which is perfectly quiet, beautiful vertical lines of color will form in the water. The slightest warming of the jar at any spot will show currents by swaying the lines.

## Currents of Air.

The movements of the air due to heating portions of it may be illustrated in many ways. To detect the currents of air some substance which will burn slowly giving off smoke without flame is very useful, such as cotton rags or strings twisted together. Paper may be prepared by soaking strips of blotting paper, or carpet paper in a solution of potassium nitrate (salt petre). The strips are then dried. On lighting they will burn without flame. The little sticks used to light fire-crackers with will answer. Now with the lighted smoke-paper, the currents of air ascending from a candle flame or lighted lamp, and those approaching the flame from the sides may be detected. The currents above a stove, register or radiator may be studied. Even those about the body of a pupil sitting still may be seen. The different places about the room may be examined to learn just where the air is coming into the room, such as open doors, windows, cracks about these, or openings of ventilators. A thorough going over the room exploring the air for currents will give a good foundation for future lessons on the larger operations occurring outside of the room, that is, the winds; and will also be the basis for lessons on ventilation to follow in time.

The hot air balloon shows how masses of warm air may rise to great heights. The children will take great delight in making a tissue paper balloon. It can be filled with air in the schoolroom by holding it over the stove or a lamp. It will rise to the ceiling and on cooling will slowly descend. If, when it is filled, it be suddenly inverted the warm air can be felt rushing up, while the cool air will crowd the sides together with considerable force.

The sending up of such a balloon with cotton soaked with some combustible fluid is somewhat dangerous in a city as it may catch fire. It is very dangerous in the dry season in the country where there is standing grain. Still the balloon may be sufficiently filled with hot air by holding it over a stove to send it up quite a distance.

The coverings of animals are adaptations to the conditions of their life, and are all interesting objects of study. Hair, scales, thick epidermis, bony plates, spines, and feathers of various forms are in endless varieties.

Feathers are characteristic of birds and are very interesting when their true meaning is seen. For a lesson on feathers, a bird freshly killed, *e. g.*, a duck or fowl from the market, and a quantity of feathers sufficient to allow each pupil to have examples of each kind in hand during the lesson. If the question were asked: "What is the use of feathers?" the answer that will usually come is: "To keep the animal warm." This is one use of feathers, but the lesson is to show that this is by no means the only one, perhaps not the most important one. (The uses are not to be told, but if possible to be brought out by the observation of the pupils.)

First of all, feathers are different in kind and have different uses. The most characteristic, or special use is for flight. For the water birds the feathers are arranged as a boat in which they can float. The bird would sink without its feathers. For all birds, feathers keep warm in in cool weather, protect from the rays of the sun in hot weather, protect from rain, from scratches and other mechanical injury in flying, or in running through brush, etc. They serve as ornamentation to distingnish each other and to attract mates.

Examination of feathers. To have a basis for comparison examine the parts of a single feather, *e. g.* a wing feather. It consists of an axis running its length called the *stem*. The hollow part of this is the *quill*. The whole of the broad portion is the *vane*. The axis of the vane is the *rachis*. The branches of the rachis are the *barbs*, and the minute branches of the barbs are the *barbules*.

The *wing* feathers and often the tail feathers are large and strong. The barbs and barbules of each feather adhere quite firmly, and the feathers overlap so that when the wing is extended it presents a broad firm surface with which to strike the air. Have the pupils separate the barbs and barbules, smooth them till they again adhere and examine them with a microscope or hand lens to determine how they adhere.

The *contour* feathers are those all over the body whose ends come out on the surface and overlap one another like shingles on a house. The barbules on the outer ends adhere as in the wing feathers. These thus fitting over each other make the outline of the body, and when well oiled as in many birds, they make a good waterproof coat. The inner ends have barbs and barbules, very fine and not united, being downy.

The *down* feathers have all their barbs very fine and diffuse. These feathers have minute quills, and being next the body are for warmth. They make a soft backing for the contour feathers and thus also give protection against injury, and help make the "float" for the swimming bird's body to rest in.

Many birds have oil glands at the root of the tail from which they get oil to rub on the feathers.

*Ornamental* feathers of many forms are interesting—such as in the tails of roosters, peacocks, etc.

The color markings on the feathers of birds may form a series of good lessons. How they are arranged; how they sometimes extend from feather to feather to make definite figures, etc.; how in some the markings are stripes so arranged that the birds can hardly be seen in the dry grass; in others, brilliant to attract the attention of mates, etc. Always, if possible, procure the bird for the lesson.

The *moulting*, or shedding of feathers is an interesting subject. Why do they moult? How often? In what manner? are some of the questions to be put. Most birds moult annually. Some, twice a year (Ptarmigans in fall get a white plumage so they may not be easily seen on the

snow; in spring, a brown to enable them to hide in weeds, rocks, etc.)

There are muscles under the skin by which birds can raise their feathers. Some of these are strong as in the crests of some birds, and in the tails of turkeys and peafowls which have the habit of struting.

If the feathers be removed from the bird and the naked skin observed it will be found that the feathers have a very different arrangement. The arrangement differs in different kinds of birds. There are naked patches, and patches covered with feathers and in the latter the feathers are arranged in rows. In some forms this definite arrangement is not so distinct as in ducks, chickens and our common birds. The children may from time to time compare forms.

NOTE.—These lessons on feathers may serve as suggestions for lessons on the coverings of other animals.

## Oxygen.

The air contains constantly oxygen, nitrogen, argon, carbonic acid, and vapor of water. The first two make up the main bulk of the air, the last three are very small in amount. We wish to study each of these gases, except argon, a recently discovered one, which in this work we cannot make or isolate. Oxygen can be made and studied with very little apparatus.

The materials used are *potassium chlorate* and *black oxide* of *manganese*. The potassium chlorate gives up the oxygen it contains very readily on heating. In fact it is liable to give off such a large quantity of gas at once, that there is an explosion. Consequently we mix with it, the black oxide of manganese which seems to retard the giving off of the oxygen.

Mix well equal amounts of the two substances. A test tube one-third full will make sufficient gas for the work. Fit the test tube with an air tight cork, and a glass tube to carry off the gas. To catch the gas, have ready at least five wide-mouthed bottles (8 to 15 oz. in size). These are filled with water and inverted in a pan of water. The delivery tube carrying the gas from the test tube is bent so that it can be made to conveniently reach under the mouth of an inverted bottle. When all is ready with the alcohol lamp, heat the potassium chlorate and black oxide of manganese mixture and the gas will rapidly come away and bubble up into the inverted bottles, displacing the water and filling the bottle. Then another bottle is brought over and so on, till all are filled or the oxgen gives out.

In beginning to apply the heat, do so at first gently and to the upper part of the test tube. This will heat the tube, and prevent moisture forming on it later and breaking the tube. Next heat the upper part of the potassium chlorate mixture, first exhausting its oxygen, then work downwards. If you begin at the bottom of the mixture, as the gas comes off, it is liable to puff the black dust up and choke the delivery

tube. After once beginning to make the oxygen, the lamp flame must not be taken away from the test tube while the delivery tube is under water. The cooling of the tube will contract the gas, and water will rush back and break the hot tube.

All the apparatus may be held with the hands. One pupil may attend to the bottles; one hold the test tube, using a thick handle of paper as a holder; another may manage the lamp. A stand and other conveniences may be used. For descriptions and figures see any elementary text book in chemistry.

NOTE.—Every single operation of the above should be questioned about, and explained by the pupil, as every step is a good lesson.

Now that we have five or more bottles of oxygen, they may be tested as follows:

In one bottle, have one of the children insert a lighted splinter. Let the fire be extinguished except a small glow at the end. Also have a small piece of lighted candle attached to a wire, thrust down into the jar.

A piece of sulphur may be burned in the next jar. A little cup made from a piece of crayon, fastened to a wire can be used to hold the lighted piece of sulphur while inserting it into the jar.

A fine iron or steel wire may be burned. The wire may be bent into a spiral form by wrapping it about a round lead pencil. To one end of the wire attach a very small splinter, or bit of sulphur to serve as a lighter. The wood or sulphur is lighted, and the wire thrust into the jar of oxygen.

To burn charcoal, a charred splinter, or a glowing coal fastened to a wire may be used.

A brilliant effect is produced by heating a teaspoonful of finely powdered charcoal to a glow, and then letting it fall into a jar of oxygen.

The burning of phosphorous gives the brightest light. Phosphorous must be handled with care. It is best to use a pair of forceps, and cut the piece to be used under water. Dry the water off with blotting paper. It lights easily by friction, and a small piece of burning phosphorous on the hand makes a painful and bad wound. It is poisonous. Handled carefully there is no danger. All small pieces must be picked up and put back into a bottle of water where it is best kept. The phosphorus is burned in the crayon cup as was the sulphur.

Now questions will arise as to what are the results of the burning in each case. The white smoke in the last is a combination of oxygen and phosphorus, so in each of the other cases an oxide is formed *e. g.* of carbon, of iron, and of sulphur. Each of the above should be repeated until it is clearly seen just what has taken place.

These experiments are so interesting to children, that they will not mind having them repeated many times. This is good in giving them clearer notions, better command of handling apparatus, and a familiarity with the facts.

## Carbonic Acid.

Most of the children have learned that there is carbonic acid in the air; that it comes from the lungs in air breathed out, and that it is made by burning lamps and candles.

As a good test for the gas will be of great service, it would be better at the very start to explain how lime water is so used. Lime water is readily made by putting some lime into water and allowing it to stand until the excess settles, leaving the solution above, clear. Pour off the clear liquid for use. It can be purchased ready made at the drug store.

A small amount of carbonic acid shaken up with the lime water makes a white substance in the water, thus giving a milky appearance. The substance formed is carbonate of lime.

One of the children can breathe air through a small amount of lime water in a test tube or other glass vessel. The lime water turns white, proving the presence of carbonic acid.

A bit of candle is placed in the bottom of a glass tumbler, which is covered with a book. The candle soon goes out. Test the gas left with lime water.

An inverted glass is held over the chimney of a burning lamp. Slip a card over the mouth and test the carbonic acid. The gas coming from various burning substances may be tested.

To make carbonic acid in a quantity unmixed with air, etc., pound up into small pieces limestone or marble; place in a wide-mouthed bottle or flask, into which is fitted a cork and delivery tube. Cover the marble with water, then pour in some muriatic or sulphuric acid. Bubbles of carbonic acid come off rapidly. As it is heavier than air of the same temperature, it can be caught in empty jars or bottles standing upright, lightly covered with cards. When a few jars have been obtained, try them with lime water, lighted candles, lighted splinters, etc. Show that the gas is heavier than air by pouring carbonic acid into a jar which contains only air, then testing this jar's contents; or pour some into a jar at the bottom of which is a lighted candle.

Many other experiments can be made with the carbonic acid, making the pupils familiar with its properties.

## Diffusion of Gases.

That gases diffuse themselves out into the air from the vessels which contain them, may be shown by leaving a jar of carbonic acid uncovered for a short time. Although heavier than air, it leaves the jar. An inverted jar of oxygen will show the same. The lighter oxygen will not stay in the jar. The same is true with illuminating gas, vapor of gasoline, of ether, etc. These experiments make it clear why in the air the different gases are thoroughly mingled instead of the heavier settling to the bottom and the lighter going to the top.

## Flowering Plants.

*The methods of forming Seeds.* In the stu ly of the flower its function of forming seeds, from the very start, should be made the most prominent fact about it, much more so than the mere names of the parts, or the forms of the flowers, and classification of the plants.

The preceding lessons on plants in which their methods of reproduction was observed will have aroused an interest in the question of how flowering plants reproduce themselves. The observation of the simple spores of mushrooms, moulds, etc., growing into the same forms; the spores of the fern growing into the little prothallium, which produces the large fern; the pine pollen carried by the wind to the cones, where it causes the ovule to grow into a complex seed, all prepare the pupil to take an interest in how the conspicuous flowers manage to form the seeds all ready to grow into the form of the parent plants.

Begin with the fact that flowers produce pollen and ovules, and that the pollen must reach the ovules before the ovules will grow into seeds. This will bring the pupils to see first the pollen bearing part, the stamens, and the ovule bearing part, the pistil.

For the first lesson, have a number of different kinds of flowers. Select one in which the parts are large and easily seen; for example, the California Poppy. Cut the flower in two by a cut perpendicularly through the center. (Or, separate the parts in any other way that suits your own views of clearness.) The cut will expose the numerous ovules in their case. Have their position clearly seen, then the case (ovary), its attachment, its upward extension into styles and stigmas. The whole is the pistil. Next find the pollen in the stamens. The parts and position of the stamen. With a hand lens it may be seen that the stigmas are covered over with pollen grains.

Explain that a pollen grain grows by a long filament (something as a mould spore grows) which reaches down through the stigma and style until it reaches the ovules. After it reaches the ovule, the ovule grows into a seed, and at the same time the ovary (and sometimes the other parts around it in many kinds of plants) grows into pods and fruits of countless forms.

A beautiful experiment showing the growth of pollen grains is easily managed with the use of a compound microscope as follows: Make a solution of sugar about 10 per cent. (one part of sugar to nine or ten of water) place a little of the sugar solution in a watch crystal, sprinkle in this considerable pollen of sweet peas. In a few minutes the pollen grains begin to grow. Examine by taking up a drop of the solution with the pollen grains in it and placing it on a glass slip, cover with a cover-glass. The pollen grains will grow while you are watching them. (The grains may be sown in a drop of the sugar solution and placed in a moist cell as shown in the demonstration.) Most pollen grains grow when treated in this way, but not all so quickly.

Examine many flowers, now in reference to their stamens and pistils, pollen and ovules. Include forms very different in appearance from the poppy. Examine also grasses in bloom.

In the poppy and the other plants at hand, next trace the growth ot the ovary into the developed fruit. Many lessons in the future will be given on the different kinds of fruiting and their relation to the distribution of seeds. But this is the best time to observe the development of their forms of fruiting.

On many plants we can have on a single branch, all stages from the pistil in the flower to the ripened pod or other forms of fruit.

For examples of very interesting and very common cases take:

The burr clover, any lupine, alfilerilla, shepherd's purse, wild mustard, wild turnip, dandelion. Any other plant cultivated, or weed, will give an interesting lesson. In each, see the use of the particular form. If you do not know the name of the plant you can yourself trace out these changes first, and then make the same process the lesson.

Following these, will be lessons on the corrolla and its use in attracting insects, and managing to get them to carry pollen from one flower to another.

## Ants' Nests.

An exceedingly interesting and instructive object for pupils of all grades is a colony of ants so kept that they can be observed in their daily work in and about their nest.

Students of ants have devised various means for thus arranging their nests. One method is to place the colony in a glass jar partially filled with earth. The mouth of the jar is covered with gauze or netting to prevent their escape. The jar should have its sides covered with a thick dark cloth, which can be removed to make observations. In capturing the colony, if possible the queen should be obtained. Soon after the ants are placed in the jar with the dirt, they will begin to make excavations, and some of their tunnels may be against the sides of the glass. If this is fortunately the case their life in the nest may be observed.

A much better nest was devised by Sir John Lubbock. It consists of two sheets ot glass of about 8 x 10 inches. These are held apart at the edges by narrow thin strips of wood, about the thickness of a lead pencil, the thickness being but slightly higher than the ants to be confined. These strips are placed between the sheets at their outer edges. At one corner a space of about a quarter of an inch is left, which is to be the door for the entrance and exit of the ants. The remaining space between the glass sheets is filled with pulverized earth, very slightly moist.

This is to be the nest. This is placed in a shallow box a few inches wider each way than the nest. Around the edges of the box is tacked a strip of fur, which acts as a fence to retain the ants within bounds.

The margin between the nest and sides of the box give a space for the

ants to wander about in, and in which to place food and water. A piece of cloth should cover the nest. A large sheet of glass may cover the shallow box to prevent too rapid evaporation.

The next step is to capture the ants and induce them to enter the nest. A colony of ants with the queen is captured as before. The queen may be distinguished by her being larger than the workers. They may be brought home in a glass jar mingled with the earth of their former nest. The whole mass of ants and dirt is placed on top of the nest prepared as above. The ants, as this dirt dries out bury themselves deep in it. Scrape away and remove all the dirt that you can from the mass from time to time. This reduction of the dirt in which they are hiding leads them to look for other quarters. They will be likely to discover the door left for them, at which point they will begin to excavate a tunnel into the prepared nest. This tunnel finally becomes a system of tunnels and passages, making their new home. In this can be studied the wonderful life of the colony, by removing the black cloth. The ants must be well fed and watered. Sugar, bits of meat, crumbs of bread, seeds of plants, are foods of different ants. This nest may be kept going for a long time. For fuller accounts consult Lubbock's "Ants, Bees and Wasps," International Scientific Series. An excellent description of an ant's nest is on page 276, Comstock's Insect Life (Appleton). $2.50.

### Making Gas.

The process of making illuminating gas may thus be illustrated:

Into a test tube place bits of wood, shavings, or sawdust. A delivery tube is fitted to this as in making oxygen. Jars for catching the gas are arranged also as in the oxygen experiment. The test tube full of wood is now heated and the gas coming away is caught. The first gas coming off is heated air from the tube. Later, gas from the decomposing wood will fill a small jar. This gas may be lighted and it will be seen to burn with a blue flame. It is a mixture of gases.

In the test tube remains carbon, the charred remains of the wood. The delivery tube will be coated inside with tar. If a larger apparatus be used, say an iron retort (this may be made of iron gas pipe) a greater heat may be used, and coal may take the place of wood, and by this means a considerable amount of gas can be obtained.

It may now be shown how in making illuminating gas, a very large retort is used; arrangements are made to separate the tar, and other substances from the gases; also those gases in the mixture which interfere with the illuminating power; that the large iron gas tank corresponds to the jar catching the gas in the experiment.

A visit to the gas works will now be of great interest, and the main processes there carried out can be clearly understood.

Now may be taught the lesson that when coal and wood burn the

very same processes take place. The wood is heated, gases are given off, which are burned on the spot. The flames of wood, coal, and oil are gas flames.

## The Candle Flame.

The special study of the candle flame will be best taken up some time after the making of gas out of wood. The pupils are to find out that it is a gas flame, the brilliant light being produced by minute particles of carbon becoming incandescent as they pass from the center portion, where no combustion is going on, through the part lying just outside of this where the gases are in active combustion. The gases which burn and the carbon which thus makes the light and is finally consumed are all from the oil of the candle being decomposed into these products by the heat, just as the same products are made out of coal by heat in the process of the manufacture of illuminating gas, and in the making gas out of wood in the experiments already given. None of these facts are to be told at first, of course.

By cutting up a few candles into short pieces each pupil can have his own flame to study.

Let each try to make out the parts of the flame. It will be found that there are four: the blue cup at the bottom; a thin, almost transparent outer sheet of flame; a brilliant light giving part just underneath this; and a dark central portion. In the dark central portion is a mass of gases charged with black floating particles of carbon (smoke). If a sheet of paper held horizontally is suddenly thrust down on the flame to about its middle and held for a short time, but removed just before it breaks into a flame, a round ring is scorched on the paper corresponding to the two outer coats of the flame. The center is unscorched and may be blackened. This is where the dark central portion of the flame was in contact with the paper. If a splinter of wood is held across the flame a short time, it will be scorched where the outer coats touch it, but unscorched where the central portion meets it.

A very small glass tube three or four inches long may be thrust into the central portion, and the outer end inclined upward. In this position it will tap the central portion, when smoke will issue from the tube. This may be lighted, and thus give us a new small flame, showing that the central portion is composed of combustible gases.

The blue cup at the bottom is just in the position where the ascending currents of air strike it to the best advantage, and insures good combustion without smoke and floating particles of carbon. This gives great heat, but little light.

The air reaches the two outer coats of the flame and combustion takes place in them. In the one next the dark center the carbon particles as has been said are passing through and glow with a bright light. They are completely burned in the outer coat.

That particles of carbon may make a colorless flame bright may be shown by sprinkling lamp black or powdered charcoal in an alcohol flame. On the other hand if with a glass tube drawn out to a fine point, or with a blow pipe air is blown well into a candle flame, the whole of the flame will become blue, no longer giving out much light.

The better supply of air makes a more prompt combustion of all gases and carbon, but with the result of less illumination.

If the supply of air to the candle flame is interfered with it smokes, much of the carbon and gases escaping unconsumed.

The smoking lamp, the smoking fire means a poor combustion. In each case the smoke may be reduced by a better supply of air. Questions may be proposed which will explain the advantage of lamp chimneys, smoke stacks, tall chimneys and other devises for causing better combustion.

Cooling the candle flame by thrusting into it a cold substance, such as a bar of metal, causes it to smoke. Carbon burns only at a high temperature, and in this case much heat is lost to the cold subtance.

Those substances which contain much carbon, such as turpentine, camphor and sealing wax may be made to give out a very black smoke. The carbon may be caught as soot or lamp black, which subsequently can be burned.

In general we depend upon the carbon for the light in the illuminating flame, but in the calcium light a very hot flame is used to heat a piece of lime (calcium oxide) to a white heat, which gives out the bright light. In the stereopticon, oxygen and illuminating gas is used to heat the lime. In the class room a blow pipe and an alcohol flame can be made to give a bright glow to a piece of lime sufficient to illustrate this point. In the experiment alreadv given of burning the magnesium ribbon, it is the white dust, the magnesium oxide resulting from the combustion that gives the light.

The foregoing should be broken up into many lessons. These will suggest many others. The applications of what has been given are very numerous, and if well followed out will make clear many things in every day's experience with lights and fires.

## Metals.

The metals may be made the subjects of a large number of lessons. The lessons may be extended to the *uses* of the metals, such as found in the house, in the car, in the shop, and wherever the pupil may discover them. Following these, there may be in some of the grades a limited number of lessons on the ores of some of the metals, the location of mines, methods of mining and extracting the metals. In any grade the study of the common metals, their properties, and uses may be taken up.

Provide for work with the metals: a file, a hammer, a thick piece of

iron to use as a small anvil (a flat iron with sometimes the smooth side up and sometimes with the pointed side up will serve well), a knife with a strong blade, a large iron spoon, and a large alcohol lamp, or other method of getting a strong heat.

Begin the lessons with lead, copper, zinc and iron in the form of strips, or of thick wire. These may be examined carefully in respect to the appearance of each, then each tested with the above instruments by the pupils; their properties, the relative hardness, flexibility, action under hammer, file and knife, and ease of melting. Very small wires of each would allow the comparison of strength of each. If rods of equal sizes are equally heated at one end the pupils may easily detect by holding the other ends of the rods, the relative quickness with which they are heated. Allow them to find also which tarnishes or rusts most readily. When the properties of each are well seen, have the pupils seek in the next few days' experience the places where these metals are used and why they are so used in the positions in which they were found.

Of course in some cases, properties which the pupil has not discovered, such as its relation to electricity, or such considerations as economy, may have led to the use of the metal.

After these lessons any metals of the list of available ones may be taken up and examined in the same way, e. g.: Aluminum, nickel, platinum, silver, gold.

Some of the more rarely seen and interesting metals can easily be obtained, such as antimony and bismuth, beautifully crystalizing, easily melting; mercury, a liquid that is melted even at low temperatures; sodium and potassium, which are lighter than water and burn when they touch ice or water; magnesium, a thin strip of which will burn in air with a most brilliant light when lighted with a match.

Space will not allow the detailed directions for the numerous lessons that may be made with all of these metals. A possession of the metals (easily obtained) consultation of encyclopedias and works on chemistry for further facts in regard to them and experimentation with them, and some ingenuity on the part of the teacher will supply the details which will make this series sufficient in amount and interest to extend with the intervals of other subjects through some years.

In this connection are to be examined some of the more common alloys, such as *brass*, *type metal*, *solder*, *gun metal*, *bell metal.*

The sources mentioned above will also give information in regard to the composition and uses of these alloys.

## The Pendulum.

The pendulum as our time marker and its importance in relation to time-pieces is sufficient excuse for making some simple lessons with it as the subject.

Suspend a small weight from a convenient place by a strong thread,

thirty-nine inches long, the length counted from the point where the thread is attached to the center of the weight. Have the pupils determine how many times in a minute this pendulum vibrates. If it does not vibrate sixty times in a minute correct the length till this is its rate. Keep this pendulum as the time keeper for the succeeding experiments.

Have them make other pendulums of the same length, some with much heavier weights and some with lighter weights and determine if there are differences in the rate.

Have the pupils construct a pendulum long enough to vibrate once in two seconds, and one short enough to vibrate twice in a second. Let them measure and compare these with the seconds pendulum. Do the same for pendulums vibrating once in three seconds and three times in a second. A high ceiling, a window or a tree will give an opportunity for hanging a long pendulum.

The use of the pendulum as a time instrument can now be explained. The importance of accurate and uniform time in business and in railroad and other travel, etc., etc., may be seen. On Mt. Hamilton every day at noon a pendulum in a fine clock stationed there, is connected by electric wires with most Western Union Telegraph Offices on the Pacific Coast. In any one of these offices at noon anyone can hear the telegraph instrument beating in unison with the pendulum on Mt. Hamilton. Thus all time pieces might be kept in accurate accord with this one.

In other parts of the United States are centers from which the time is sent out in the same way over all that region.

The story of the discovery of the properties of the pendulum and the effect of its application to time-keeping could be made interesting and profitable. (See Encyclopedia, etc.)

Note the relation of the pendulum to falling bodies; the effect on the pendulum if the earth were heavier or lighter; if the pendulum were near or father away from the center of the earth, might be taken up in some of the grades under certain conditions, but would perhaps better be deferred at present.

## Silk Worm Moths.

When a good supply of mulberry leaves can be obtained, silk worm moths offer excellent opportunities for observing with small trouble the whole cycle of the life of this group of insects.

If some of the eggs be obtained and placed in some convenient place in a warm room, they will in a few days hatch out into very small caterpillars. These should be immediately fed with fresh mulberry leaves. They will feed voraciously on the leaves, never leaving the place where they are kept if the supply of leaves is kept up. After feeding and growing for some time they come to a period in which they are ready

to spin cocoons. They like some dry twigs to crawl upon and attach their cocoons to. From the cocoons later come out the moths. As these cannot fly, there is no danger of their leaving. After fertilization, the females will lay an immense number of eggs. These she will distribute over the piece of paper or cloth on which she may be placed. These eggs, of course may be used to start a new colony. If it is desired to keep the eggs for a considerable time without hatching, say, over winter until mulberry leaves come again, they should be kept in a cool place, neither too dry nor too moist. An ordinary cellar is a good place. The length of the time of each period in the cycle of the life of the moth depends on circumstances of temperature and supply of food. In all stages the silk worm has its enemies, such as mice, rats, birds and predaceous insects. Of course they must be protected from these if a successful colony is to be maintained.

There is so much available information in regard to silk worms and silk culture, that the teacher can easily arrange to extend the information gained by the observation of the colony in the school-room.

## The Moon.

A study of the motions of the moon makes a good beginning toward a clear understanding of the apparent and real motions of the sun, moon and stars.

On the first evening that the moon can be seen after "new moon" have the pupils note how near it is to some star. Venus may be in a good position near the moon. On the following evening they are to note again its relation to this star. They may make their notes by making a sketch of moon and star each night. The changing shape of the illuminated part of the moon is also to be noted each night. Soon the moon will be so far from the star that it cannot well be used to mark the progress. Then another star nearer to it in its new position may be used as the mark.

At first only these notes are to be taken. After the moon has made considerable progress among the stars, inquiries may be started as to what is taking place. Most, if not all the pupils will know that the moon, in common with the sun and the mass of stars, among which they move, rises in the east and sets in the west daily, and they will know that the cause of this apparent motion is the earth's revolution. But most of them will be surprised to find that the moon moves east among the stars. These observations may be carried on and discussed by the pupils until they make out for themselves that this is the motion of the moon around the earth.

The time of revolution may be determined by noting the date when the moon passes some "fixed star" until it passes it again.

If the pupils understand circles and degrees, a simple apparatus can be arranged by which they can determine approximately the number of degrees it moves in every twenty-four hours.

Provide a rod about four feet long sharpened at one end, so that it may be thrust into the ground (a tripod is more convenient, but more difficult to make).

The upper end has a platform of board about four inches square, on which to place a level, by means of which the platform is to be made horizontal. A small iron spirit level can be obtained for fifteen cents.

On the edge of the platform is tacked a thick card board with a semicircle drawn on its outer side. The diameter of the circle lies on a level with the surface of the platform. The semicircle is marked off in degrees as carefully as possible and marked from 0 degrees to 180 degrees, the 90 degrees being on the end of the radius exactly perpendicular to the surface of the platform. With this apparatus, using pins as sights, the position in degrees of the moon above the horizon may be read for a few scccessive evenings at the same hour. See if the rate of movement thus determined corresponds to the rate calculated by the observation of how many days the moon takes to make a revolution (360 degrees).

Another line of questioning to be pursued is what is the cause of the changing of the illuminated part. Pupils may in their own way prepare models to illustrate this.

Why is one side of the moon always turned toward the earth? How long is the moon's day?

All the above, children from ten to twelve years of age have worked out with no trouble except the setting of the work. This work of course must be given out for the pupils to do at home of evenings, but if by any chance the teacher might meet some of them, some evenings much more interest might be obtained. A small telescope, or even good spy glass will add greatly to the interest.

After the above work the pupil can more successfully understand the motions of the earth.

[NOTE.—If the pupils do not know that the "fixed stars" maintain their same relative position, they may be set to watch any group of them for successive periods. The motions of some of the planets among the other stars may be later made subjects of observation.]

## Formation of Course of Study.

While the above constituted the directions formerly given out many other subjects have been incidentally suggestsd, that have been more or less connected with them. Many of these have been taken up by some of the teachers and further supplemented.

It is the design to make this and a more extended experience with Nature Study the basis upon which to work out a course of study in this line, adapted to the different grades. It is recognized that any such a course of study formed now should not be regarded in any other light than tentative. It should be agreed upon that it should at any time be

changed in whole or in part, if its arrangement does not produce the most satisfactory results. While this is not the place to discuss further such a course of study, it may be proper to state that one thing seems clear in regard to such a course, that it is of advantage to see early in working upon its plan. That fact is, that a course in Nature Study for the elementary grades should not be a single definite series of objects, one set to be used year after year in the same grade. But rather it should consist of a number of possible subjects from which choice can be made according to conditions governing each week of the year. The progress aimed at is not so much an increasing knowledge of an arbitrarily selected series of objects, as progress in seeing, thinking and expressing, and in a growth in the knowledge of and a sympathy with the world about us. Respectfully submitted,

O. P. JENKINS.

Stanford University, September, 1897.

Compliments of the Author

# PROGRESSIVE

# NATURE STUDIES

BY

G. W. CARVER, M. AG.,

INSTRUCTOR IN AGRICULTURE AT THE
TUSKEGEE NORMAL AND INDUSTRIAL INSTITUTE,
TUSKEGEE, ALABAMA.

Price 5 Cents.

TUSKEGEE INSTITUTE PRINT,
1897.

# PROGRESSIVE

# NATURE STUDIES

BY

G. W. CARVER, M. AG.,

INSTRUCTOR IN AGRICULTURE AT THE
TUSKEGEE NORMAL AND INDUSTRIAL INSTITUTE,
TUSKEGEE, ALABAMA.

Price 5 Cents.

TUSKEGEE INSTITUTE PRINT,
1897.

ANYONE DESIRING COPIES OF THIS WORK OR ANY INFORMATION CONCERNING IT MAY ADDRESS THE AUTHOR.

# PREFACE.

In presenting this list of Progressive Nature Studies for your consideration, I do not for a moment presume that there are no good books or outlines upon the market, because there are many excellent ones.

Neither do I write to improve upon them, only as it touches our peculiar needs.

The entire series will be composed of gleanings from a large number of our standard works, with some additions of my own.

Respectfully submitted,

G. W. Carver.

## TO THE TEACHER.

In the very beginning, every teacher should realize that a very large proportion of every true student's work must lie outside the class-room. Therefore, the success of these outlines will depend largely upon your efforts in their presentation.

The study of Nature is both entertaining and instructive, and it is the only true method that leads up to a clear understanding of the great natural principles which surround every branch of business in which we may engage. Aside from this, it encourages investigation and stimulates originality.

This common fault is apparent in all outlines pertaining to this work. Students invariably want to discuss the topic, rather than give you a direct answer. This is not permissable, neither what he or she may think, unless their thoughts are based upon facts. There is nothing to be deplored more in the class-room than to hear a number of pupils pretending to recite and constantly telling you what they think with reference to matters that the intellectual world has recognized as a fact decades ago.

See that each student is prepared with slips of plain white or manilla paper, for making sketches, and insist on their work being kept very nice and clean; securing such as may be worthy for exhibitive purposes.

The following method of grading has proven very satisfactory:

Grade (a)—The best.

" (b)—Poor.

" (c)—Rejected.

Every energetic student will aspire for Grade (a). This grading only applies to neatness, as some will naturally draw better than others.

## OUTLINE NO. I.

### LEAVES.

(a) Are they all alike?

(b) If not, tell me in what ways they differ?

(c) Bring a specimen of each one to class to-morrow.

(d) Hold an oak leaf to the light and tell me what you see.

(e) What are the little veins for? (Teacher explain.)

(f) See if the veins in all the leaves are alike

(g) What plants retain their leaves all winter, and by what general name are all such plants known?

(h) Of what value to the plant are the leaves? (Teacher explain.)

(i) Draw as many different shaped leaves as you can find upon the paper mulberry, and bring to class.

(j) What leaves have commercial value?

### STEMS.

The teacher should at this point make clear any misunderstanding with reference to stems.

(a) Are stems all round?

(b) Draw the shapes of as many different stems as you can find.

(c) Are they all solid? If not, why are some hollow? (Teacher explain.)

(d) Bring ten different stems to the class, and be able to tell in what ways they differ.

(e) Of what use are stems?

(f) Do you know of any that have commercial value; if so, what are they?

(Teacher enlarge upon this.)

### FLOWERS.

(a) How many kinds of flowers grow in your own door-yard? Bring one of each kind to class.

(b) How many can you find between the class-room and your home? Name them.

(c) Bring as many different shaped flowers as you can find to class.

(d) Do all flowers have odor—(smell?)

(e) What is the odor for, and why does it differ in different kinds of flowers? (Teacher explain.)

(f) Do you know of any flowers that have commercial value? If so name them and state what is made from them. (Teacher explain.)

(g) Of what value to the plant are the flowers? (The teacher should see that the proper answer is given here.)

### EXPERIMENTAL WORK.

The teacher must give his personal attention to each experiment, and see that it is successfully performed and the proper conclusions drawn.

This work is designed to strengthen actual scientific and practical research, and to further develop and round out originality, freedom of thought and action.

EXPERIMENT I.

Take one each of the following leaves; cotton, collard and wild cactus, place side by side on a board, either in the sun or shade. leave for several hours. What changes have taken place in the leaves? Why?

EXPERIMENT II.

Take a number of stems, leaves and all from any growing plant (or a variety of them,) fill a glass tumbler with water, insert the bouquet of plants; examine the next day. Where has the water gone.

EXPERIMENT III.

Take from the brook or pond some leaves and stems of the common arrow-head (water lily), carry some in your hand and put an equal number in a tin pail and cover tightly with the lid; carry for some time this way, say half an hour. Contrast (compare) and tell why they look differently, if so.

TREES.

(a) Name the different kinds of trees on the school grounds.

(b) How many of these have you at your home?

(c) Are they as pretty as ours? If not, why?

(d) How many upon the school grounds have real commercial value, and which do you consider the greatest in value? Why?

(The teacher must see that the proper answers are given here. See that they make

an effort, and do not accept "I don't know, sir," as an answer. Let them find out from their parents, work it out themselves or in any way they choose.)

### SHRUBS.

(a) Name the different shrubs on the grounds.

(b) What is the difference between a shrub and a tree?

(c) How many of these have you at your home, and how do they compare with ours?

### WRITTEN WORK.

This work will appear repeatedly all through these outlines, and is to be given at the teacher's discretion, and may be enlarged upon or diminished as necessity demands. Its main object being to train the pupil to say the most in the fewest number of words.

It also teaches three important adjuncts to good scholarship, viz: Condensation, precision and clearness.

The work is as follows, and should not contain more than forty-five words.

(1) Trees as a whole.

(2) Some one tree, giving the following points:

(a) General character and name.

(b) Size and locality in which it grows.

(c) Kind of seed and its use.

(d) Its value to us.

### EXAMPLE—WHITE OAK.

The white oak grows in rich bottoms, has a large body and spreading top; bark white and rough; leaves coarse and deeply

notched; seed an acron, eaten greedily by hogs. This tree is largely used for lumber, posts, shingles and baskets.

FRUIT.

(a) What is fruit? (Teacher explain fully.)

(b) Bring ten different kinds of fruit to the next recitation.

(c) Are they all of value; if so what? (Teacher explain.)

(d) Take any kind of fruit, such as an orange, lemon, apple, squash, peach, pear, cucumber, pumpkin or potato, split open and observe numerous small thread-like bodies, forming a net work all through the fleshy portion. What are these threads, and of what use are they? (Teacher explain )

(e) Are all fruits round? If not, name some that have other shapes

(f) Bring six to the class that are not considered round

(g) What ones usually assume a round shape and why? (Teacher.—This question should be fully understood before leaving.)

(h) Does the Irish potato (white potato) bear fruit?

(i) Sweet potatoes.

(The teacher should make clear any trouble here.)

SHAPES.

(a) Notice the general shape of the following trees. and be able to tell in what ways they differ, viz: elm and magnolia, persimmon and water oak, pear and apple tree, blackgum and sweetgum, hickory and yellow poplar, chinaberry and cedar trees.

(b) Study them in the same way with reference to branching

(c) Study the leaves and fruit of each one in the same way.

(d) Has any of this fruit commercial value; if so, what ones?

(Teacher.—See that they answer correctly here, and explain any misunderstanding.)

(e) How many kinds have you at home? Name them.

WRITTEN WORK.

(a) Walk briskly for twenty minutes, covering as much territory as possible; tell what you saw.

(Teacher.— Too much stress cannot be placed upon the importance of this request, as the object here is to train the mind to comprehend at a glance what passes before the eye )

(b) Take a plot of ground, anywhere on the campus, ten feet square, study it for twenty minutes and write the result of your observations

(Teacher.—Here minute details are desired.)

(c) Examine the woodbine growing on Alabama Hall and tell what holds it to the wall.

(d) Describe the Principal's door-yard, as follows:

(1) Bring only the outline.

(The teacher should give plain, simple instructions here, with reference to outlines, taking some other yard or similar subject as an illustration, and in all written work, rigidly strike out every useless word

and expression, discourage any attempt to soar, but lay much stress upon an easy, free and graceful style of composition.)

(2) The composition complete.

ONTARIO AGRICULTURAL COLLEGE
Macdonald Institute

BULLETIN 134

Hints on Making

# Nature Collections

In Public and High Schools

BY

W. H. Muldrew, B.A., D. Paed.
Dean of Macdonald Institute

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE

PRINTED BY L. K. CAMERON
Printer to the King's Most Excellent Majesty
Toronto, Ont., June, 1904

BULLETIN 134 May, 1904

Ontario Agricultural College and Experimental Farm
MACDONALD INSTITUTE

# Hints on Making Nature Collections in Public and High Schools

By W. H. MULDREW, B.A., D. Paed, Dean of the Macdonald Institute

## INTRODUCTORY.

A short time ago the Macdonald Institute issued its first leaflet to teachers on the subject of Nature Study. The replies already received show that such assistance as was there proposed is a very real need of the schools, and will be appreciated by the teachers.

The present bulletin treats one aspect of the subject with some detail and is intended to be kept in the schools for permanent reference. It may seem to emphasize the rural and agricultural sides of the question, but this is inevitable from the nature of the subject. The surrounding conditions of country life favor Nature Study for the same reasons that cause Manual Training and Domestic Science to be welcomed in the cities. This does not mean that Nature Study is to be ignored in the urban schools, but rather that its development there will follow somewhat different lines. Other phases will be dealt with in later numbers.

As a centre of interest for the Nature Studies of a school, there is nothing more helpful than a collection of suggestive things from the outdoor world. The value is, however, in the *making* and the *using* rather than in the *keeping*, and this bulletin is intended as a guide to teachers and pupils in beginning such work. We need hardly say that collections, like books and other tools, are but the means, while the end is to be found in the interest that is aroused and the thought that is stimulated.

It is not to be expected that all of these suggestions will be practicable in our schools at once. Teachers have many duties to take up their time and attention, and Nature Study must be content with small beginnings, until it can shew itself worthy of a place with the older subjects of the school-room. The important thing is to make a beginning, however small, and then to grow with the work as results may warrant.

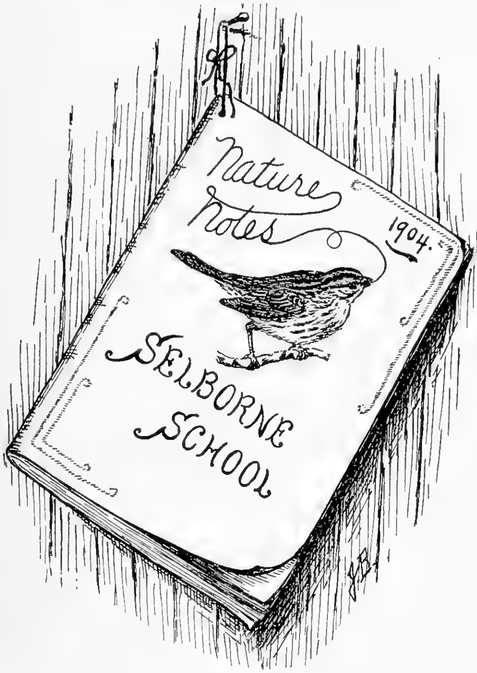
In recent years, local Fairs have given prizes to schools for nature collections, and in some places excellent sets have been shown. The weakest point with these has been want of method and uniformity in the preparation of exhibits which should follow some general system, It is very probable that such competitions will be encouraged more and more in future years in connection with the larger Exhibitions as well as at the smaller Fairs, and it is therefore important that there should be some general standard for the guidance of teachers and scholars.

In the preparation of these instructions assistance has been received from the staff of the Agricultural College. Prof. Lochhead has contributed many practical suggestions besides preparing the sections dealing with insects and aquaria. Most of the illustrations have been prepared for this bulletin by Mr. John Buchanan, B.S.A., of the Experimental Department. Thanks are also due to Mr. F. W. Hodson of the Dominion Department of Agriculture for suggestions gained from his pioneer experiences in introducing school children's exhibits in Nature Study at local Fairs.

This suggestion as to exhibits at local fairs has the hearty sympathy of Mr. H. B. Cowan, Superintendent of Agricultural Societies for Ontario, who is making them one of the important features of exhibitions and fall fairs. Mr. Cowan is now preparing an illustrated pamphlet dealing with this subject.

---

## Collecting Ideas from Nature.




Outdoor nature is full of interesting things and events. Little eyes and ears are quick to see and hear, and little minds are quick to think. Suppose we help them to keep a record of the happenings of this outside world. A simple note-book and a pencil supply the needed outfit; five minutes in morning or afternoon supplies the time; the children will gladly supply the ideas. A brief discussion, a few suggestive questions, and a permanent record will form a worthy lesson to begin the day's work and will not lose its effect. Is there a teacher who cannot do as much? Give date, place and name of observer with all needed particulars. Let older pupils make their own entries, but give equal credit to the earliest efforts. Use only the right-hand pages reserving the opposite for later notes and explanations.

What things may find a place in these Nature Notes? All things of interest to children or to the community, in the world of Nature. We suggest a few classes of items from the endless variety supplied by the changing seasons. The aim will be to form the habit of observation rather than to collect information, but the facts will have a value and interest of their own.

Fig. 1. Taking Notes.

(*a*) First things of the season: the return of the common birds, as Robins, Crows, and Bobolinks; the northern or southern flight of Geese, Ducks, and

Gulls; the appearance of hibernating animals as the Woodchuck, Chipmunk, Snake, and Bat; the awakening of the Frogs; the leafing and flowering of the Trees, the opening of the wild Flowers; the re-appearance of Insects as Butterflies, Mosquitoes, Potato Bugs; the coloring and falling of leaves in Autumn.

(*b*) Events of interest: frost, snow, rain, hail, rainbows, new and full moon, eclipses; the beginning and end of sleighing; plowing, sowing and planting, haying, harvesting, potato-digging; making maple sugar; going fishing or berry picking; the birds building nests or feeding their young; crows pulling corn or eating grasshoppers; the young of wild or domestic animals; the swarming of bees; use or harm of birds and insects; tracks of animals in winter.

(*c*) Histories of growth, with descriptions and drawings showing changes from day to day; notes on the condition of some chosen development, as, for example,

(1) A plant from a seed.
(2) A tree, from bud to leaf and flower and fruit.
3) A bird's or wasps' nest.
(4) A field of grain or roots.

Records of things like these would form a very interesting book. The inspector would be glad to see it. Next year it would be doubly valuable for comparison. A careful summary would be welcomed by any good local paper. It would add much to an exhibit at the autumn fair, for it would shew thinking as well as collecting, and the very best one in the Province would make an excellent bulletin for the schools in 1905.

## Living Collections.

It is not necessary that specimens should be dead and dried, for living things are always of greater interest. Neither is it necessary to keep birds or animals or frogs or fishes in the school-room, though even this has been done with profit, and an aquarium for the development of tadpoles, small fishes, insects, etc., is quite practicable in some places. Potted plants are already common in the windows of well kept school-rooms.

But trees and shrubs are easily planted and form a permanent living collection of constantly increasing value. They attract the birds and other forms of life and shelter the wild flowers. In this way they

prepare for wider Nature Study, and, therefore, deserve first attention. Arbor Day need not be limited to one day, but should rather keep pace with a growing interest in trees and plants. No school can afford to neglect the planting of trees and shrubs to beautify its grounds and interest its scholars.

In transplanting from the bush or from a nursery a few simple rules should be kept in mind. The tree joins itself to the soil by fine fibrous roots, and these should be disturbed as little as possible in the uprooting. The roots should also be protected from sun and wind and brought into close, firm contact with the earth in their new home. This is

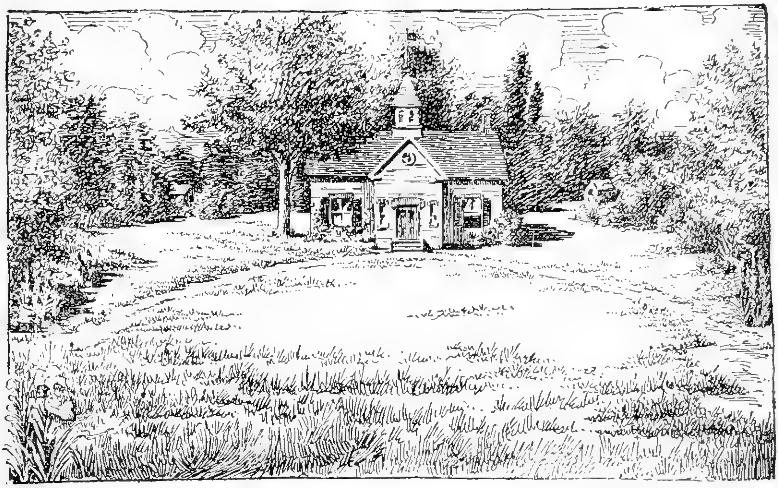


FIG. 2. From Bailey's "Hints on Rural School Grounds."

secured by trampling and pounding good soil (with water added if convenient) around and between the roots, in a hole rather broader and deeper than seems necessary, so that no air spaces can exist. All this is best done in cloudy or rainy weather; but in any case many of the roots will be lost, and the top must be reduced in proportion. There is little danger of over-trimming, for a healthy stem will produce new branches if able to support them.

The Ontario Agricultural College is preparing to grow seedlings of forest trees for the use of farmers who wish to change waste land into

woodland. It is very probable that such nursery seedlings will be offered to schools that have shown an interest in such matters, and that will be willing to protect them and study their growth. School grounds may thus become object lessons in forestry for the farms of the neighborhood.

School gardens are now attracting much attention as an aid to Nature Study, and they are encouraged by a special grant from the Department of Education. Such means improve the children as well as the grounds, and have a permanent influence over the whole neighborhood.

FIG. 3. Insect life in winter.

At a recent meeting of the Canadian Forestry Association in Toronto a gentleman described such a garden made in the grounds of the school where he taught twenty-five years ago. It had trees and shrubs from the neighboring woods and flowers grown from seeds, all planted and cared for by the teacher and pupils. The trees are now a foot or more in diameter, and farmers' wives in that section still grow flowers descended from the little school garden. That teacher is now a member of Parliament for the same constituency, and deserves his promotion as well as the familiar bouquets still brought him by his old pupils. Was it worth while to take a little trouble with that little school in the days when Nature Study had not yet received a name?

Our illustration shows a collection of living things with no signs of life. These are cocoons of moths and butterflies gathered during the winter and waiting to be awakened from their sleep of transformation. In the autumn they were caterpillars; the warmth of spring, or of the school-room, will bring them out as beautiful winged creatures.

An aquarium may be arranged for the study of water insects and animals. Failure to keep a healthy and sightly aquarium often attends the efforts of a beginner through neglect of proper care and management. The secret is to imitate Nature, i. e., to make conditions similar to those of some pond where water life flourishes, and to get a good balance of water plants and water animals. When this balance is established the aquarium requires but little attention beyond the addition of water. Large battery jars and preserve jars serve admirably for this purpose.

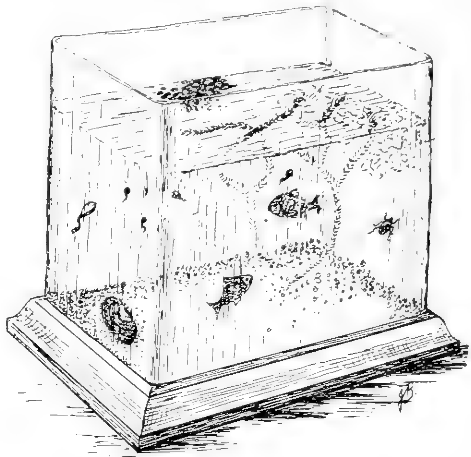


FIG. 4. A very small pond and its people.[1]

The following common water plants and animals are suited for aquaria: Duckweed, water-milfoil, stone wort, waterweed, snails, water-scavengers, beetles, water-boatmen, back-swimmers, mosquito wrigglers, caddice-worms, etc.

## Collections of Pressed Plants and Leaves.

A flower that has withered and dried in the usual way is useless; it has lost even the likeness of its growing self, and has become brittle, faded and crumpled. But if dried instead between sheets of porous paper under heavy pressure it retains much of its original color and strength in a form that is very convenient for examining as well as for preserving and exhibiting. When thus prepared and mounted on a suitable card with a proper label it forms a useful permanent specimen for study or comparison.

To prepare plants properly in this way, the following materials will be needed: Drying paper (carpet-felt or coarse porous paper), sheets of tea-paper (or smooth newspaper leaves), two pieces of smooth board 12 inches x 20 inches; a few weights (suitable stones of about 10 lbs. each will answer); mounting paper, in sheets 11 inches x 16 inches or 8 inches x 11 inches; liquid glue or strips of gummed paper; labels showing botanical and common name, date, place and collector; a collecting box or vasculum and a note book.

The entire plant, as far as possible, should be in the collection. When this is impossible, as with trees and shrubs, branches with leaves, or leaves and flowers, should be collected and preserved. In drying

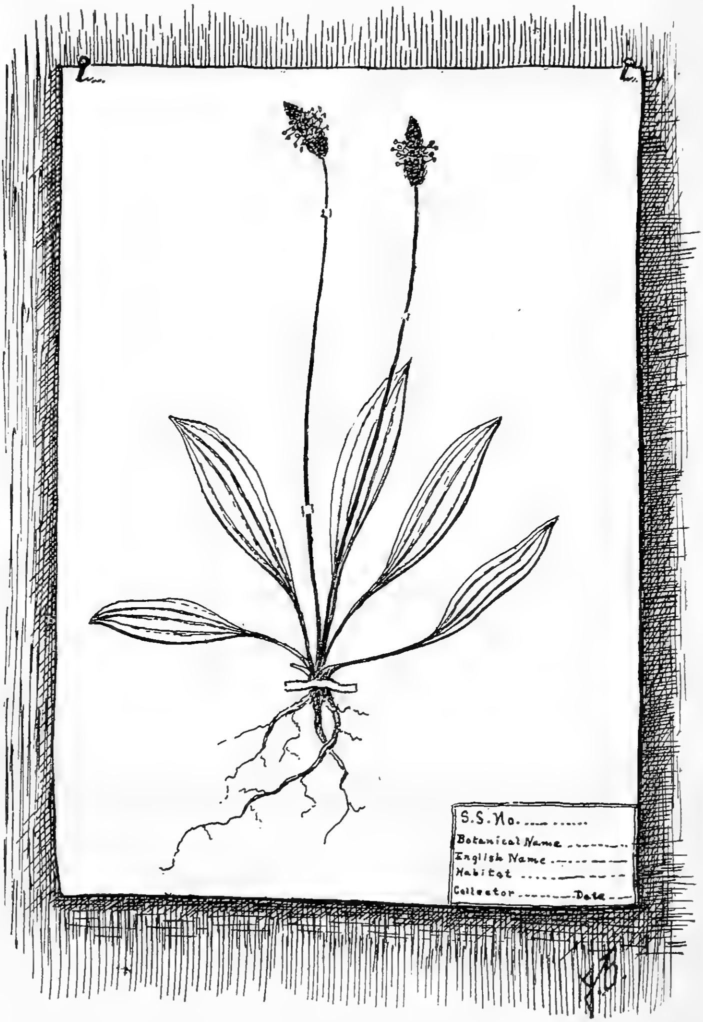



Fig. 5. _A specimen properly mounted. What weed is this?

plants, care should be taken to secure the specimen (free from outside moisture) without breaking any portion of it. It should be spread very carefully between two leaves of tea-paper with sheets of drying paper

above and below. Many plants may be placed one above the other, separated by drying paper, and pressed at the same time by weights on the upper board. When a plant is placed thus to be dried, a note should be put with it, stating its name, the date of collection, the locality where it was collected and the collector; for one must not trust too much to memory in these matters. The collection will very likely grow rapidly and experience will soon show the need for keeping notes of every plant collected. Carpet-felt makes excellent drying paper, and can be obtained at most dry goods stores for about four cents a square yard. Instead of tea-paper, ordinary newspaper, cut up into convenient sizes, may be used. The secret of drying plants well is to change the dryers frequently. The more water the plant contains the more frequently should the dryers be changed, and in some cases this might be done daily.

When the specimen is thoroughly dried it should be mounted on a sheet of stiff white paper or cardboard, about 11 inches x 16 inches. For smaller plants, one half this size, 8 inches x 11 inches, will answer very well.

Suitable mounting paper may be obtained from Mr. F. W. Hodson, Dominion Live Stock Commissioner, Ottawa, at a rate of 50 cents per hundred sheets of the larger size. Mr. Hodson will also supply schools with suitable printed labels free of charge. The latter must be carefully filled out and gummed to one corner of the card, while the plant is securely fastened in position by glue or strips of thin gummed paper.

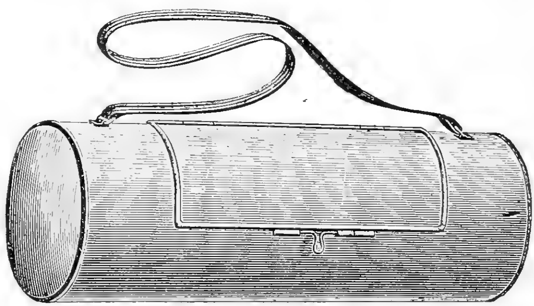


Fig. 6. A Collecting Box.

A close tin box or vasculum about 18 inches long and of a shape suitable for carrying by a shoulder strap, is very useful for collecting fresh plants, and may be easily made by any tinsmith.

## Collections of Grains and Grasses.

Specimens of mature grains, grasses or clovers may be easily prepared and form an interesting exhibit. These should show the complete

plant, root, stem, leaves and heads, (or merely the heads with a few inches of stem) with the name of kind and variety in every case. Such

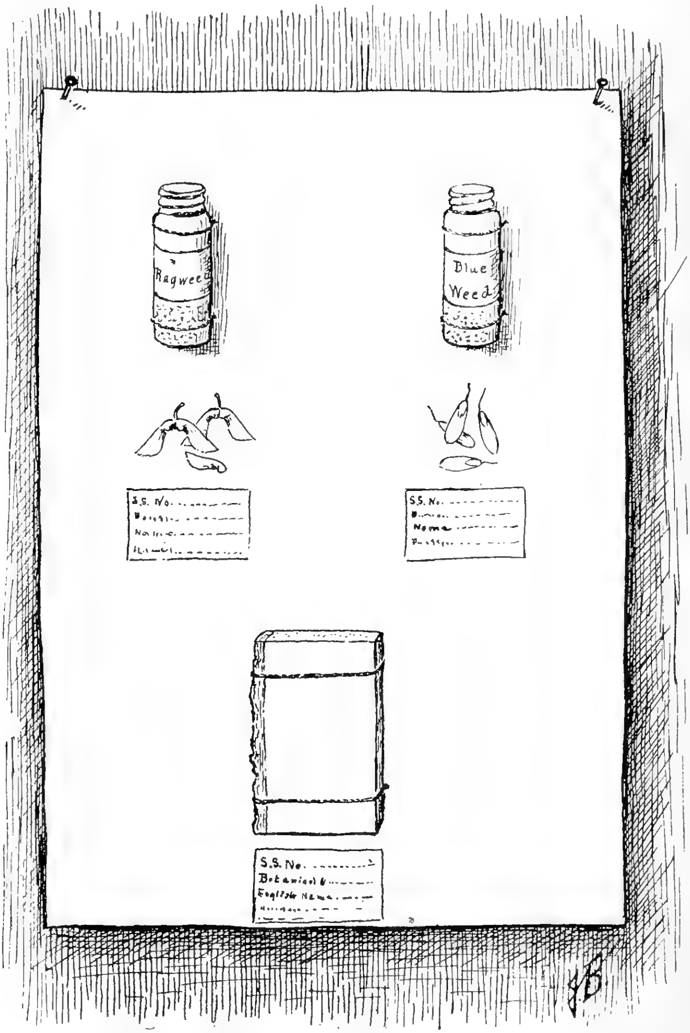



FIG. 7. What are the Tree Fruits?

plants may be pressed and mounted on the usual card by carefully bending the stalk when too long or they may be kept straight and tied in bunches, supported, if necessary, by a light rod or lath.

## Collections of Seeds and Dry Fruits.

It is worth while to learn to know the seeds of noxious weeds that are often mixed with the seed of grain, grass, or clover. These should be collected and kept in suitable small bottles with proper labels. The best vials for this purpose are of clear glass with wide necks and closed by a metal screw-cap. Those holding 1 drachm are of suitable size, being about 2 in. x ½ in and can be secured through local druggists at a cost of 15 to 20 cents per dozen.

These vials are best shewn on sheets of cardboard to which they are secured by loops of cord or elastic. Seeds must be quite ripe and dry to prevent moulding, and the pods or heads should be enclosed as well as the clean seed.

The dry fruits of trees and shrubs are equally interesting and may be fastened in the same way, or by means of glue or mucilage, on similar cards. The keys of the Maples, the acorns with their cups, the winged fruits of Ash, Elm, and Pine all serve for important lessons on the reproduction of trees and the distribution of their seeds. Many Canadians have never seen the seed of the Pine; and many can see no connection between the cones at the summit and the seedlings at the foot of the giant of the forest. A collection of tree seeds carefully mounted and named is an excellent lesson on forestry.

## Specimens of Wood.

Sections of wood from the various kinds of trees form an interesting and useful collection. These should be prepared in such a way as to shew the bark, and two planed surfaces. The size should be 3 inches in length by 1 inch in width, by ½ inch in thickness. Such pieces may be neatly fastened on cards like those used for pressed plants and should be labelled in the same way.

It is better to use sections from the body wood of the trees, but this is often inconvenient and the size given above can be very easily secured from a branch without destroying the tree. Similar sections shewing the work of insect borers or of woodpeckers may be mounted in the same way and will be very useful.

## Collecting and Preserving Insects.

Insects may be collected at all seasons of the year, but the best time is undoubtedly the summer months. Many collectors find the moths and butterflies most interesting on account of the extreme beauty

of their wings; others find greater interest in beetles; still others prefer the study of groups which are not so beautiful to the ordinary observer. Insects of special harm or use, for any reason, are always interesting

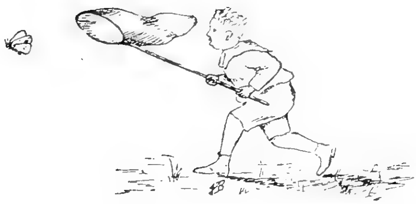


FIG. 8. The Boy and the Insect.

The great majority of the moths must be caught at night for they rest during the day time. Most of them are readily attracted to lights, and may be secured by devices such as trap lanterns. Many insects are also attracted readily by sweets, such as sugar or molasses, and if a sweet solution is brushed on the bark of trees, moths frequently gather at such trees after dark and are easily captured.

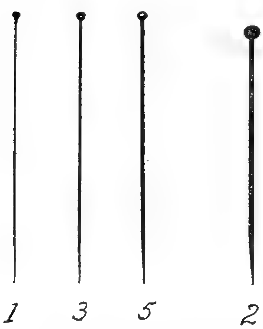




FIG. 10. 1, 3, 5, Insect Pins.
2. German Steel Pin.

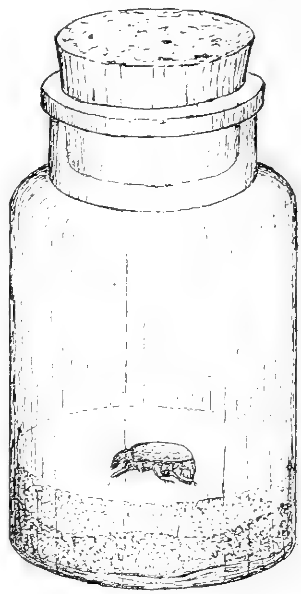


FIG. 9. The Poison Bottle.

The following articles are needful for collecting: Cyanide bottles, one or more; insect pins; cigar boxes or insect cases; spreading boards, different sizes; date and locality labels; larvae bottles

The cyanide bottle is needed for killing insects before they can be pinned. (Fig. 9.) This bottle may be made as follows by any druggist: Place two or three lumps of cyanide of potassium, of the size of beans, in a wide mouthed bottle, pour in sufficient water to cover the lumps, and add enough plaster of paris to take up the water. If the bottle is left uncorked for a short time, the plaster will rapidly set and harden. Care should be taken not to inhale the poisonous fumes which come from this bottle, nor to leave the cork out for any length of time, for the cyanide would soon be lost through the escape of the fumes. It is often desirable to place a circle of thick blotting paper on the surface of the plaster to absorb any moisture which may form.

Insect pins do not readily rust when placed through the bodies of insects. Probably the best are made of German Silver. They may be be obtained in assorted sizes from Alex. Stewart, Druggist, of Guelph, at a cost of 25c. per package of 150, post paid. The most desirable pins for the ordinary work of the collector of insects are Nos. 1, 3, 5,—No. 1 being suitable for small insects, No. 3 for insects of medium size and

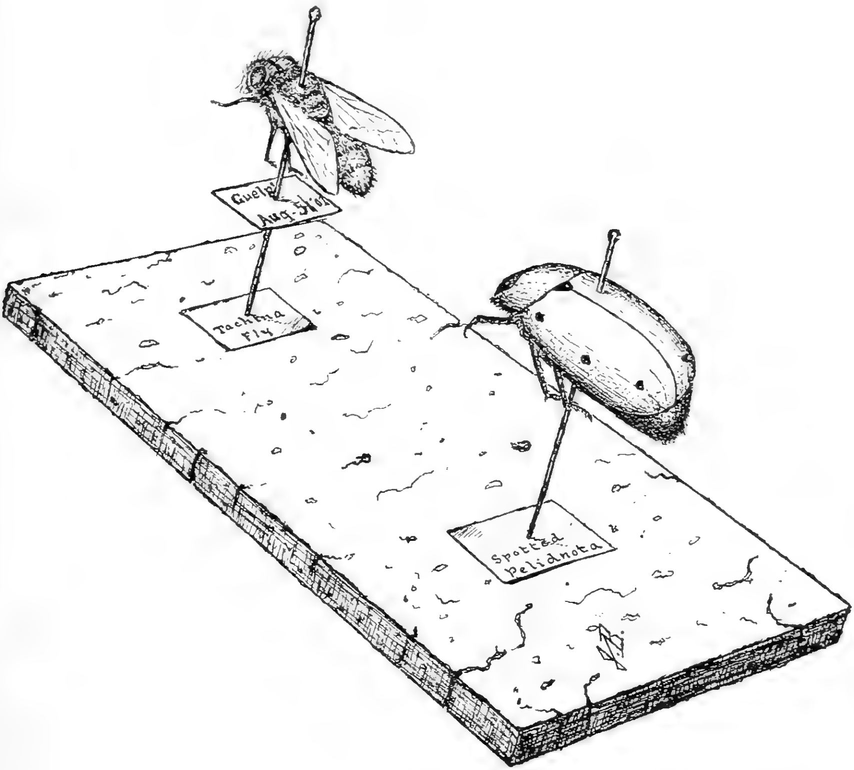



FIG. 11. Method of Pinning.

No. 5 for insects with large bodies. German steel mourning pins with glass heads are second best, and may be had at any dry goods store. Care should be taken when pinning insects to thrust the pin through two-thirds the length so that from one-third to one-quarter of the pin projects above the back of the insect. The beetles should be pinned through the right wing cover; other insects through the thorax, or that part of the body just back of the head. (See Fig. 11.)

A handy boy can readily make an insect net for himself. All that he requires is a broom handle, three feet of stout wire, a little heavy sheeting, and one yard of cheese cloth. The wire can be bent into a circle of about ten inches in diameter and the ends fastened firmly into the end of the broom handle. The cheese cloth is made into a bag and attached to the band of sheeting which folds over the wire. (Fig. 12.)

The collector will be a little awkward at first in the use of the insect net, but with practice the wiliest and most rapid of insects may be captured. Care is needed in transferring the insects from the net to the cyanide bottles lest the wings and legs should be injured.

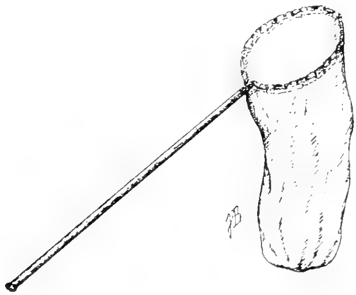


FIG. 12. The Insect Net.

FIG. 13. The Insect and the Boy.

Moths and butterflies when captured seldom die with their wings outspread so it is necessary to use spreading boards for those forms which we desire to preserve in this position. (Fig. 14) shows the construction and use of a spreading board. Two pieces of pine, fastened together by cleats at the end, are left wide enough apart to admit the body of the insect. Narrow strips of cork are then tacked on the under side of the pine strips so as to form a bottom to the groove and to serve as a support for the pin upon which the insect is placed. Another broad strip is nailed to the cleats and forms the base of the spreading-board. Of course the insects must be pinned to the spreading-board before they have time to become brittle, and while they are in a relaxed condition. It will require some patience and skill to spread the wings of the smaller moths without injuring them, but practice will make perfect.

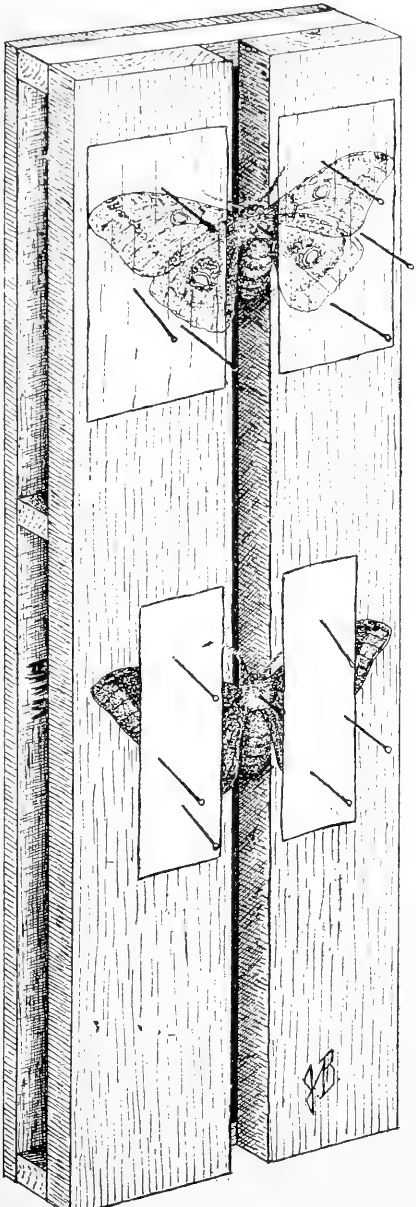


FIG. 14. The Spreading-board.

Cases are necessary for holding and displaying the insects captured. At first the collector may use cigar boxes very satisfactorily, but the time will come when he will not be satisfied with anything less than good insect cases, which will keep out dust and minute insect pests. The bottoms should be lined with sheet cork which can be purchased from dealers in insect supplies, or with bottle wrappers obtained from druggists. For exhibition purposes insect cases should have glass covers, if possible. Collectors who wish to make their collections look tidy, neat and artistic may line their cases with fine, glossy white paper. This improves very much the appearance of the collection as a whole.

Every specimen which has been placed in a collection should have a date and locality label and a name label attached. These labels may be written free hand or they may be printed with pen and ink. Printed labels, as a rule, look much better than written ones. The proper time to place date and locality label upon the insect is at the time of pinning, and it is usually placed below the insect about a third of the way up the pin. The name label is placed near the bottom of the pin.

With regard to the preservation of the larvæ of insects, much may be said. It is important that collectors should preserve the larval forms as well as the other stages of the insect for it should be borne in mind

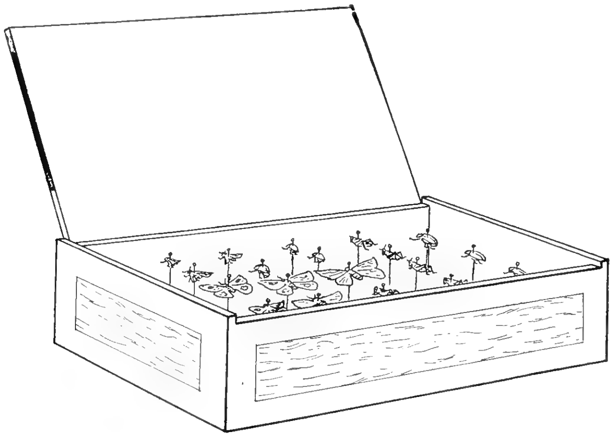


FIG. 15. A Simple Insect Case.

that those collections are of highest value educationally which show the life history of the insect in all stages—the egg, the larva, the pupa and the adult. The larval stage of the insect, moreover, should be carefully

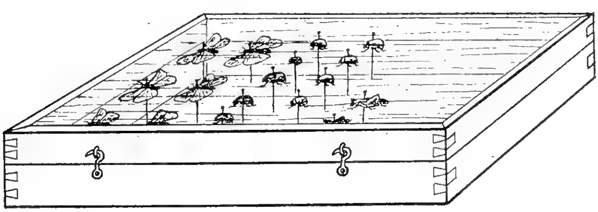


FIG. 16. A good case with glass cover. Specimens not labelled.

preserved throughout all its molts for the mature larva frequently differs considerably from the younger forms. Some collectors place the larvæ in liquid in vials; other prefer to inflate them and have them placed on pins beside the adult forms. For school purposes, however, the vials are to be preferred.

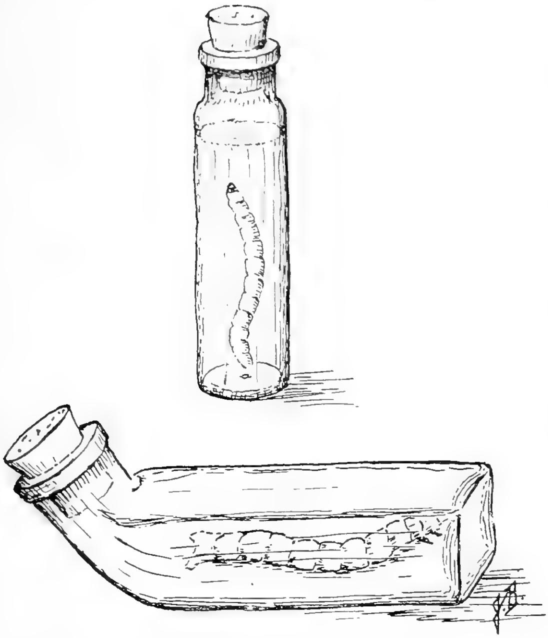


Fig. 17. Vials for preserving larvæ in liquid.

A good preserving liquid may be made as follows: 50 parts methylated alcohol, 50 parts water, 4 parts formalin. This mixture can be prepared by any druggist at a cost of about 25 cents per pint. It must be kept closely corked as it evaporates very readily. Special bottles with bent necks are very suitable but rather expensive, costing about 5 cents each. Two drachm homœopathic vials with wide mouths may be obtained from druggists at much lower rates and will answer very well.

## Historical Collections.

Objects that link the past to the present are of great educational interest and value. Such things are found in every neighborhood, and the school is the proper place for their keeping and interpretation. The boy who has picked up an ancient arrowhead or pipe from the site of some long-forgotten village may well feel a personal interest in the early exploits of Huron and Iroquois. But we need not go back to Indian times for relics of the past. The early pioneers of our own race have disappeared, too, and their primitive weapons, tools, and manufactures are hardly known to the children of to-day.

How much true history would be suggested by a few articles from a settler's outfit of 100 years ago? The flint-lock musket, and the smooth hollowed stone used for grinding grain by hand, are almost as far removed from the present as are the tomahawk and the bow-and-arrow. Those who possess such relics would often be glad to place them where they could be assured of permanent care and usefulness to successive generations of children.

Articles of this class should be carefully numbered and described in a note-book or by means of tickets securely fastened to them

Small objects are best fastened on cards in the same way as specimens of wood described on page 10

Such a collection needs little care or preparation, and if properly used will be both interesting and instructive.

Mr. David Boyle, of the Education Department, Toronto, is our best authority on all that pertains to these relics of our past history, and he is always ready to assist collectors in understanding their "finds." In case of doubt or difficulty he will be glad to hear from teachers and scholars, and will be able to explain most of the objects that come under this heading.

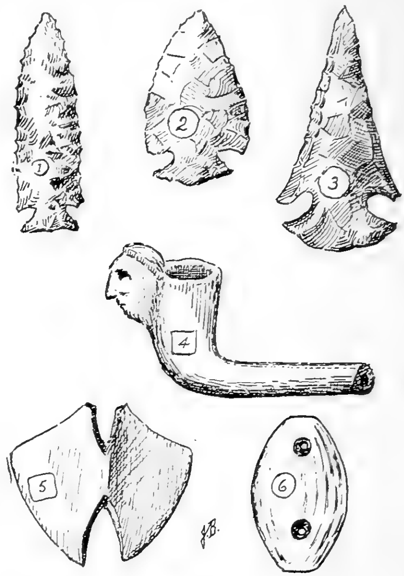



FIG. 18. What are these? Who made them?

The Provincial Museum, of which Mr. Boyle has charge, is one of the best, in Archæology, on this continent, and specimens of more than local interest should be deposited there for public use and safe-keeping. Due credit will be given for all such donations which will be exhibited over the name of the collector.

FIG. 19. What birds are these? Where is their nest?

## MISCELLANEOUS NOTES.

There are many things not mentioned previously that might find a place in a good school collection of natural objects. Such are specimens of the work of animals: Birds, insects, squirrels, etc. The wasps were the first pulp and paper makers just as the beavers were carpenters and architects and the birds weavers and masons. This work is worthy of careful study and can be easily kept in a school-room.

Boys often collect birds' eggs, but this is a destructive practice and should be discouraged in every way in the making of children's collections. A careful descrip-

tion of a nest and its eggs with dates of building, hatching and flying in the "Nature Notes" of the School-Room is far better than the ruined home with its empty shells. It should be known also that the destruction of harmless birds or their eggs is an offence punishable by fine or imprisonment. In this way the law recognizes the value of the birds in destroying insect enemies of farm and orchard, and in entertaining us by their songs.

There is one bird, however, that deserves no such protection. It builds no nest at all but lays its egg along with those of one of its neighbors where it hatches out and bullies the honest nestlings, often causing their death. When such an egg is found in a nest it should be destroyed for the sake of the others. What bird is this ?

FIG. 20. One of the earliest spring birds colored "like the sky above and like the earth below." Did you ever find the nest?

In many places very good local collections of rocks and minerals may be made. These should be ticketed or labelled so that their names and localities may be readily seen, and in the case of useful minerals the composition should also be stated in some simple way. For instance, magnetic iron ore might be shown as containing nearly three-fourths of its weight of iron, or crystalline marble as merely a form of limestone.

Stones or pebbles which show the action of natural forces like frost, running water, etc., have an interest and a use without regard to the materials which they contain. Specimens of fossil animals or plants are of great value as illustrating the simple world-history, now taught in connection with physical geography.

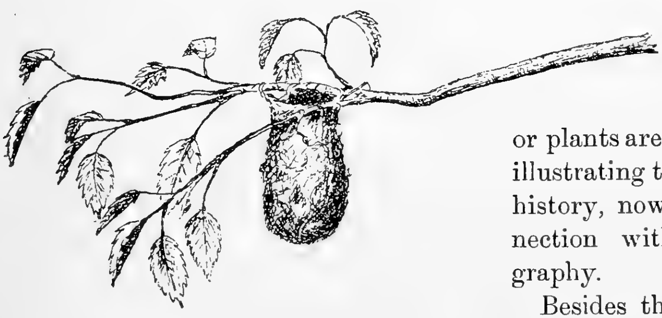


FIG. 21. A good drawing. Do you know this nest and its owner?

Besides the actual objects as here described representations such as pictures, drawings, water-color paintings and photographs from nature are all valuable additions and can be used to beautify the

school room as well as to improve the minds of the pupils. Scholars should be encouraged to draw sim plenatural objects, and the best work should become a part of the school collection. This is one means of cultivating the natural fondness for expression by drawing and coloring which has been too little helped by our schools.

### Books on Nature Subjects.

The Department of Education now grants liberal assistance to school boards in forming libraries for public schools, and many such have been established in recent years. Each of these should contain good books of reference in the various departments of Nature Study. Children should be encouraged to use these in supplementing their observations, but never as text-books or as substitutes for original work. The teacher, too, needs the help of suitable books of reference and cannot do his best work without them. We give here a list of recent Canadian books; similar lists of American publications may be had from booksellers or publishers.

| | |
|---|---|
| Guide to Nature Study, Crawford; Copp Clark Co. - - - - | .90 |
| Modern Nature Study, Silcox & Stevenson; Morang & Co. - | .75 |
| Public School Nature Study, Crawford; Scott, Dearness and Elliot; Copp Clark Co. - - - - - - | .40 |
| Agriculture, James; Morang & Co. - - - - - | .30 |
| High School Botany, Pt. 2, Spotton; Gage & Co. - - - - | .60 |
| Sylvan Ontario, a guide to our trees and shrubs, Muldrew; Briggs. | .75 |
| Birds of Ontario, McIlwraith; Briggs - - - | 2.00 |

The following publications may be had free by teachers upon request to the Department of Agriculture, Toronto:—

Reports of Entomological Society.
Birds of Ontario in relation to Agriculture, - - Nash.
Nature Study, or Stories in Agriculture - The Staff of the O. A. C.
The Weeds of Ontario, - - - Harrison and Lochhead.
Insects and Plant Diseases. - - - Panton and Lochhead.
The Teaching of Agriculture in our Public Schools, - James.
The Grasses of Ontario, - - - - Day and Harrison.

# THE OPINIONS AND EXPERIENCES OF TEACHERS AND INSPECTORS.

## EXTRACTS FROM LETTERS RECEIVED IN ANSWER TO THE FIRST MACDONALD LEAFLET ON NATURE STUDY.

---

*"Within a short distance of our School, we found stratified rocks showing marble and limestone; a perfect miniature glacier; a canyon forming the gorge of a little Niagara; rocks in all stages from blocks 6 ft. by 8ft. on the hillside, to the finest sediment on the plain below; roots petrified by the action of lime in the soil. Thus we saw in our own little world the action of the same forces as are seen in the Alps, in Colorado, in the Nile and Ganges, or in the fossils of past ages." (Condensed).*

*"Every Friday afternoon he devoted to this study, but it did not meet with the approval of the parents or Trustees. The objection was that 'He was filling the children's heads with nothing but nonsense about weeds when they should be learning Arithmetic and Writing,' and so of course Mr. Blank got his discharge."*

*"What is the attitude of the teachers? Never hear them mention it except when we appear at a Convention, and we hear a lecture on it and it is good, then we say so and forget all about it."*

*"What are the most serious hindrances? Downright neglect of the teachers, also no definite work to do on the subject. It betters discipline by making the teacher and pupil more conversant."*

*"The teachers are willing, but they do not know how to set about the work intelligently. They are so willing, and the clamor for some such work has been so incessant that they are ready to follow any method that offers. I do not think that the word 'clamor' is too strong. I have talked to many intelligent people in rural districts, and while there is no demand for such a thing as Nature Study (because they do not know it by this name), there is a strong feeling that much of the time of the child could be put to more profitable use, and that education should be of more practical service."*

*"I have heard the question asked repeatedly, How are we to teach a subject about which we know less than the pupils? How can we act as guides where we know nothing?"*

*"In the schools I have, for over half a century, endeavored to inweave the methods of Nature with the ordinary methods. In the Press and on the Platform, I have strenuously urged a revolt against the old Parrotism which made Memory a lumber garret and Heart and Intellect rooms to let; and a loyal return to the long outraged Queen, a submissive*

*study of her will, her ways, her beauties and her mysteries. Years have but increased my contempt for the Rote system of Cram, (not teaching), a system which 'put the cart before the horse'; a system which taught Names before Things, feeding the child on symbols without realities, and leaving him at last stunted, nauseated, paralyzed. He might pass Examinations as these things go, but those who never 'passed' passed him in the race of life."*

*"How am I to educate 135 teachers in Nature Study? Shall I hold a Summer School, or what is to be done?"*

*"I have taught all grades of Public and High School Work, and am a Specialist in Science, yet I must confess to you that I am unable to meet the demands of this new line of work."*

*"We cannot too soon do away with the dry, uninteresting second and third readers. We want lessons on the animals, birds and plants of our own country, and not those lessons on things which are never seen except at a circus."*

*"Your letter comes like a ray of sunshine to me, for as yet I see no possibility of being able to take a special course in Nature Study, and I know that I have wasted much valuable time and lost many golden opportunities in not being able to take up the work properly. I know so little that when I try to follow a plan I am lost, and hitherto I knew not where to apply for information and assistance."*

*"I have heard excellent teachers of long experience threaten to resign their positions if called upon to teach all that is required by this new draft of proposed regulations."*

*"Instead of quarreling on the way to and from school, they have their eyes and ears open to find new plants, birds or animals. The gloomy days and dull Friday afternoons are brightened up by Nature Study talks."*

*"The chief hindrance I have found is the want of time. Too much importance is put on promotion examination in this county to put much time on Nature Study."*

*"The Government could help a great deal in Nature Study by giving to each school a book, containing pictures and simple descriptions of the common birds, animals, and plants of Ontario."*

*"The children can name and tell some thing about nearly all the birds in this neigborhood. I know them only as they tell me, and they often bring me new plants and ask me about them. Very frequently, I do not know and cannot find what they are, and thus lose excellent opportunities."*

*"The size of our grounds would not permit a school garden, but all the school children in the city were given seeds to take home and care for, and at the end of June we are to have a flower show in the rink. Each child is to bring his best plant for exhibition."*

"*The practical work in this study began in the school as the result of prizes offered by the Local Fair for School Children's collections of Natural objects. The Inspector was in thorough sympathy with the work of introducing this study into the schools and made a special visit to his schools with a lecturer on Nature to encourage them to undertake the study and collection of one class at least, of natural objects.*"

"*We made a beautiful collection of colored autumn leaves which I waxed and the children mounted on our heavy mounting paper.*"

"*There were no ill effects on the other studies or discipline. On the other hand it seemed to be almost a recreation from the heavier studies where its facts were often made use of, and tended certainly to a closer relationship between the teacher and pupil.*"

"*My pupils were very much interested in the work and saw a great many things during their walks to and from school that they had not taken any notice of before we began our collection. The weeds we were not able to classify we sent to the Experimental Farm and thus found their names. I enjoyed the work thoroughly and my pupils did also. We had very few books except some Bulletins from the Agricultural College.*"

"*About four years ago we started keeping a record of the first appearance of different kinds of spring birds, date of appearance, observer, and remarks. We have kept these records from year to year. Pupils have learned to see the birds and know and love them, to study their uses and relations to the rest of Nature. Some of our most destructive boys have become the birds' best friends. We have brought the flowers and ferns of the woods into the school and planted them in our window-gardens. Marsh-marigolds, hepatica, violets stored away in the fall, we have blooming in the windows before the snow is off the ground.*"

---

## NOTICE.

During July of the present year a Summer School in Nature Study for Teachers will be held at the Macdonald Institute. The work will be suitable for public schools, and the fee will be nominal. Full particulars may be had upon application to the Dean.

(No. 7)

# NATURE STUDY OUTLINES

For the use of the teachers of the state.

BY

IOWA STATE HORTICULTURAL SOCIETY

AND

STATE AGRICULTURAL COLLEGE

EDITED BY

JOHN CRAIG,
AMES, IOWA.

# SUGGESTIVE OUTLINES

## Bearing Upon the Introduction

...of...

# NATURE STUDY

....into the....

## Schools of the State.

......Authorised by the......

## STATE HORTCIULTURAL SOCIETY

....and....

**Prepared by Members of the Faculty of the Iowa Agricultural College, Assisted by Miss Julia E. Rogers, East High School Des Moines, Iowa.**

---

INST. PRESS.

# CHAPTER I

## INTRODUCTORY

### TO THE TEACHER.

BY THE EDITOR.

The following pages are the result of a combined effort on the part of the State Horticultural Society and the Iowa Agricultural College to place some outlines before the teachers of the rural schools which might be followed, with the hope of interesting the pupils in some of the natural things about them. The Horticultural Society has in view the advancement of the horticultural interests of the state by developing a love for, and a knowledge of plants, in the hearts and minds of Iowa school children. The Agricultural College labors for the promotion of accurate, systematic, and business-like farming, in other words, scientific farming.

Agriculture may not be a pure science but at all events it can only be successful when based upon scientific principles coupled with business-like practices. As it is difficult to distinguish between the business of agriculture and the science of agriculture, so it is much the more difficult to separate horticulture from agriculture in a manner reasonable and appropriate. In their fundamentals they are identical. They differ in ultimate details only. It follows therefore that a pupil interested in some branch of the great realm of nature is likely to be drawn into the field of agriculture, and if not, is at least the better equipped to enjoy life in the highest and best manner.

That the State Horticultural Society and the State Agricultural College should co-operate with the State Superintendent of Education in the initial steps of this movement is appropriate and gratifying. In no way can the happiness and welfare of the rural classes be accomplished so fully as by giving them an intelligent interest in and knowledge of the common things which surround them in every day life.

This kind of study has been aptly termed "Nature Study." It has been more accurately defined as "Seeing the things one looks at, and the drawing of proper conclusions from what one sees." It is not the study of any science in as much as it is not systematic and orderly. It indicates study and observation and engenders a sympathetic bond between observer and object.

Nature Study has progressed rapidly in New York schools. It

has been successfully introduced into Indiana and has come to many a harrassed and fretful pupil as a welcome recreation. What nature study is and how it may be introduced into schools is admirably outlined in Teacher's Leaflet No. 6 issued by the College of Agriculture of Cornell University, Ithaca, New York. In this leaflet Prof. Bailey says, "The proper objects of Nature study are the things which one oftenest meets. Today it is a stone, tomorrow it is a twig, a bird, an insect, a leaf, a flower.

"The child, or even the high school pupil, is first interested in things which do not need to be analyzed or changed into unusual forms or problems. Therefore problems of chemistry and of physics are for the most part unsuitable to early lessons in nature study; but it is often difficult to secure specimens when needed especially in liberal quantity and still more difficult to see the object in perfectly natural condition. Plants are more easily had and therefore more practicable for the purpose, although animals and minerals should by no means be excluded.

"If the objects to be studied are informal, the methods of teaching should be the same. If nature-study were made a stated part of a curriculum, its purpose would be defeated. The chiefest difficulty with our present school methods is the neccessary formality of the courses and the hours. Tasks are set, and tasks are always hard. The only way to reach nature-study is, with no course laid out, to bring in whatever object may be handy and to set the pupils to looking at it. The pupils do the work,—they see the thing and explain its structure and meaning. The exercise should not be long, not to exceed fifteen minutes at any time and above all things, the pupil should never look upon it as a recitation, and there should never be an examination. It should come as a rest exercise whenever the pupils become listless. Ten minutes a day, for one term, of a short, sharp, and spicy observation upon plants, for example, is worth more than a whole text book of botany.

"The teacher should studiously avoid definitions, and the setting of patterns. The old idea of a model flower is a pernicious one, simply because it does not exist in nature. The model flower, the complete leaf, and the like, are inferences, and pupils should always begin with things and not ideas. In other words the ideas should be suggested by the things, and not the things by the ideas. "Here is a drawing of a model flower," the old method says, "go and find the nearest approach to it." "Go and find me a flower," is the true method, "and let us see what it is."

"Every child, and every grown person too, for that matter, is interested in nature-study, for it is the natural method of acquiring knowledge. The only difficulty lies in the teaching, for very few teachers have had any drill or experience in this informal method of drawing out the observing and reasoning powers of the pupil wholly without the use of text-books. The teacher must first of all feel the living interest in natural objects which it is desired the pupils shall acquire.. If the enthusiasm is not catching, better let such teaching alone.

"All this means that the teacher will need helps. He will need to inform himself before he attempts to inform the pupil. It is not neccessary that he become a scientist in order to do this. He simply goes as far as he knows, and then says to the pupil that he cannot answer the question which he cannot. This at once raises his estimation in the mind of the pupil, for the pupil is convinced of his truthfulness, and is made to feel—but how seldom is the sensation!—that knowledge is not the peculiar property of the teacher but is the right of any one who seeks it. It sets the pupil investigating for himself. The teacher never needs to apologize for nature. He is teaching simply because he is an older and more experienced pupil than his pupil is. That is just the spirit of the teacher in the universities to-day. The best teacher is one whose pupils the farthest out-run him.

"In order to help the teacher in the rural schools of New York, we have conceived of a series of leaflets explaining how the common objects can be made interesting to children. Whilst these are intended for the teacher, there is no harm in giving them to the pupil; but the leaflets should never be used as texts to make recitations from. Now and then, take the children for a ramble in the woods or fields, or go to the brook or lake. Call their attention to the interesting things which you meet—whether you understand them yourself or not—in order to teach them to see and to find some point of sympathy, for every one of them will some day need the solace and the rest which this nature love can give them. It is not the mere information which is valuable; that may be had by asking some one wiser than they, but the inquiring and sympathetic spirit is one's own.

"The pupils will find their lessons easier to acquire for this respite of ten minutes with a leaf or an insect, and the school-going will come to be less perfunctory. If you must teach drawing, set the picture in a leaflet before the pupils for study, and then substitute the object. If you must teach composition, let the pupils write upon what they have seen. After a time, give ten minutes

now and then asking the children what they saw on their way to school."

The above advice offered to the teachers cannot easily be improved upon. It is quite as applicable to Iowa teachers as to New York teachers. In the outlines which follow are contained suggestions which may guide the teachers in the beginnings of this good work. I trust these outlines will be studied by the teacher and applied in the most fitting manner. Teachers who desire something more specific on horticulture are reminded that the State Horticultural Society has a permanent officer, its Secretary, resident in its rooms at the Capitol building, Des Moines, who is ready and qualified to assist them: that the Iowa Agricultural College at Ames has a trained staff of scientific workers and teachers who may be depended upon to render assistance whenever called upon. The opportunity is offorded, let us improve it.

It is not expected that every teacher will find the following outlines adapted to the needs of his or her pupils; it is hoped, however. that some of the suggestions may be helpful to each one and that they will be put into operation. Before taking up the suggestive lessons which follow, I am pleased to offer the thoughts of an Iowa teacher who has had considerable experience in presenting to teachers and pupils various phases of the nature study movement; Miss Julia E. Rogers, of the East Des Moines High School, writes as follows: "The first question is a natural one: 'How shall teachers get ready to do this Nature work?' And then: 'Is there some book that we can get that has the subject written up for us?" How natural, habitual is this question! But I answer you, let the books alone for awhile. Come out into the fields and woods. Drink in the spirit of the summer. Give yourself up to it. Let it reach you through all the avenues of your being. Now get the poems of Wordsworth, the writings of John Burroughs, and Richard Jeffries, and Maurice Thompson, and the rest of them. 'Are these works on Pedagogy and Nature Study Methods?' They are not. But don't you care. Forget the dusty schoolroom, if you can, and among the shadows of the trees let these inspiring writers lead you into that kingdom which is promised to those who seek it. 'Except ye become as a little child ye cannot enter in.'

If such an experience as this can be yours this summer, I congratulate you. To feel an intimacy growing up between yaurself and the world of plant and animal life all about you is to feel also an intellectual warmth and joy that is unlike anything felt before --a feeling that binds you to nature by cords that strengthen every day.

"And now comes to your mind the vital and practical question: "How shall we present this nature study to our pupils?" "Shall our already over-crowded daily program become further congested by the addition of a new subject?" The good sense of the teaching profession says 'No.' "Shall we throw out something and put Nature study in its place?" Again the answer is 'No.'

"Nature study comes not to destroy but to fulfill. It is not a single subject to be classified and scheduled for so many hours per week—to be measured as to volume and quality by set recitations and final examinations and percents. Since the moulds are all full, why not let this one thing keep its natural form and comliness?'

"Some people take beautiful, fragrant apples and laborously convert them into "butter." Shades of Pomona! And there are teachers who would take Nature Study, flower of all the pedagogies, having the dew of its youth and the beauty thereof, and systematize it till it fits into some scheme.

"There is nothing formal or conventional or systematic about the ideal Nature study lesson. The teaching of sciences is good in its proper place. But this is the teaching of children.

"Put away formality. Come down from your platform for a little while. Sit down among the children with some interesting thing in your hand and in theirs. Lead them to tell all that can be learned about it by close observation. Lead them to find out the significance of what they see. Do not exploit your own knowledge of a subject until all other resources are exhausted. It is far more important to awaken an interest in the subject than to store the mind with facts about it. Make Nature Study a recreative exercise. It is not neccessary to have stated times for its recurrence. Fill in odd moments with it. It is wonderful to note the revelations of truth and beauty which we get from the careful examination of the common, every day things that we used to consider beneath our notice.

"A very little botany will prepare us "to read the secret of a plain weed's heart," and in such study we continually add to the resources of life—to our capacity of appreciation and enjoyment of all that is going on in the great world out of doors. Knowledge gained at first hand is doubly valuable, for with the knowledge always comes an educational blessing. And this blessing you know how to bestow upon the children whose steps it is your privilege to guide.

" 'How much time shall we devote to Nature Study?' You must answer this question yourself. If you have the nature love

strong in you, the season will invite you—the interests of the children will guide you. "Fifteen minutes a day", some one says. Very well. Fifteen minutes spent each day in the close scrutiny of some interesting object—now a leaf, now a plant, a pebble, a bird or an insects, with an occasional trip to a pond, or an orchard, or to the park—will bear a wondrous harvest. Behold how great a matter a little fire kiddleth! And nothing sets the hearts of boys and girls on fire as does this natural study of natural things.

"Follow the children home—ask the parents what their children talk about and you will find out how constantly the child mind turns back to that which is to it the most real and interesting. "Correlate" is a good pedagogical word. We hear a great deal about it. What better common factor than Nature Study for the correlation of the various branches we are called upon to teach?

"A glass may be brimful of water, and yet we may gradually add a spoonful of sugar and it will not run over. The teacher's daily cup is full; but let her put in Nature Study—gradually, quietly,—and it will sweeten the whole, and her cup will not run over."

# CHAPTER II.

## NATURE AND ORIGIN OF THE SOIL.*

All the plants grown upon the farm or in the garden grow in the soil; even those that appear to be growing in streams and marshes have their roots in the soil beneath the water. Sometimes we see plants grow in water in the house or greenhouse, but most of those found there are grown in pots filled with soil. The plants found on the surface of rocks or on old rail fences are of a low, simple order. We may then conclude that most of the plants that we are most familiar with require the soil, and we therefore shall study for a while the soil, its nature, its origin, and its improvement.

KINDS OF SOIL:—Sandy soil is made up principally of sand. If we take a handful of dry sand we find that it consists of small grains that are easily mixed together. If we moisten it, it will cling together and can be moulded into various forms, but when it dries the particles all fall apart into fine sand as before. Then there is clay of various colors, sometimes red, sometimes almost white, and sometimes nearly blue. If we moisten it we can mould it, but when it dries it keeps its shape and becomes hard. We readily see the difference. When we walk over wet sandy soil and wet clayey soil, the former, when dry, readily rubs off our boots, the latter sticks. Sand is used for making moulds in the foundry and clay is used for making models by the artist; the former readily falls apart after being taken out of the boxes and can be used again, and the latter when moulded and worked keeps its shape as it dries.

Make two sets of objects, such as balls, cubes, cups, vases, or simple figure of small animals, one set from wet sand and one set from clay. Place them in the sun or near the stove and observe the effect of drying.

We see that sand as it dries does not stick together, and clay as it dries does stick together and also sticks to other objects. We now understand how it is that wet clay is sticky, it clings to the plow and the harrow and to the feet of the horses and is hard or heavy to work. Sandy soil is said to be light and clay soil to be heavy, not because of their weight, but because the former is easily worked and the latter is harder to work. If we watch closely the drying out of the two sets of objects that we have moulded we shall observe further that the sand dries more quickly than the clay; the latter holds on to the water longer. Clay soils are unusually wet soils; they are more apt to have water in them than sandy soils.

*From Practical Agriculture, James. By kind permission of Messers. D, Appleton & Co., New York.

The third class soils is unusually dark in color from light brown to dense black. such as are found in the woods where leaves and branches have decayed, and in low pastures and swampy places. This soil is made up of the refuse of leaves, branches and the roots of plants. Sometimes we can see pieces of half-decayed or rotten plants; sometimes there are very slight traces of the original form of plants. This soil has, however, all come from former plants. We call such a soil a vegetable soil, and this dark colored, loose material formed from the decay of vegetable matter is called humus. Notice how it differs from both sand and clay. It is light weight and easily worked and holds water readily.

Place a handful of swamp muck or leaf mould, humus, on an iron fire shovel and carefully set it upon the burning coals. It dries out, then burns away until only a small quantity of ash is left. Place some wet sand on the shovel and heat, and then a little wet clay. What is the result?

These, then, are three principle parts of soil—sand, clay, and humus, but in many cases we find them mixed together or one above the other. If sand is the principal part of the soil we call it a sandy soil; if clay, a clay soil: and if humus or muck, a vegetable soil. A loam soil contains a mixture of sand and clay with some humus, and such a soil is usually best fitted for growing most of the crops of the farm.

ORIGIN OF THE SOIL:—We already know where the humus or vegetable matter has come from, and, as it was formerly parts of plants, we conclude that it must contain material for feeding new plants. But where did the sand and clay come from?

Perhaps you have never before asked that question, thinking that the clay and the sand were always in the field in that form. This, however, is not the case, although they may have been there for many years, perhaps hundreds of years, perhaps thousands. Why do we say they have not been there for all time? Well, if we go to the shore of a large lake we see fresh sand being washed up day by day by the waves. If we go to the banks and mouth of a large river or even a small stream, we see sand and clay and vegetable matter washed down, carried away, and spread out to form new layers of soil. If we go to the face of a high, rocky cliff we can see the great rocks being gradually broken down and changed into piles of coarse stone, and later into finer material, and still later into sand and clay. But if we go to a range of mountains or high hills we shall see more clearly the change of great rocks into fine soil.

Under our soil we find solid rock. In some places the rock is at the surface, and we can see it becoming withered and rotten. The

outer surface is softer than the interior. In other places the rock is just under the surface. In some places we have to go very deep to find the rock, but it is always there to be found if we only go deep enough. All of our sand and clay have come from these old rocks, sand from one kind of rock, white clay from another kind of rock, blue clay from another. The nature of the soil will therefore depend largely upon the nature of the rock from which it came. This sand or clay may have come from the breaking up of the rocks that are found just under the soil: in that case the soil is likely to be shallow. But usually it has come from rocks at a distance, a long distance it may be, and has been carried to its present place by water and ice, and spread out over the old rocks.

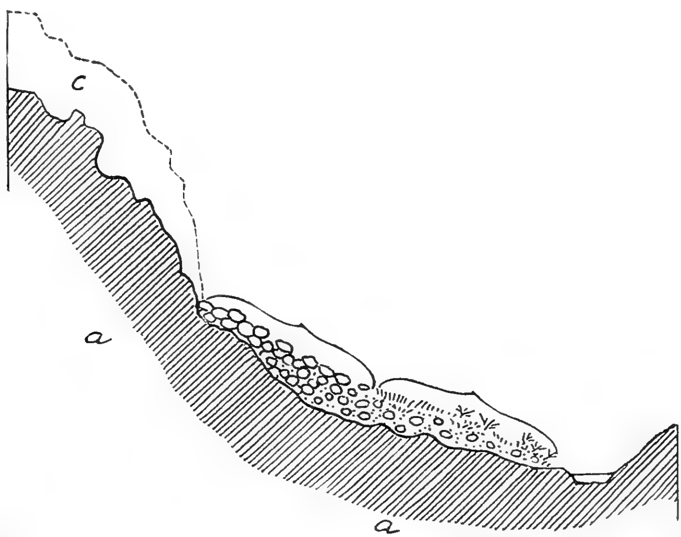



Figure 1.

Soil formed from a rock at a distance. *a* is solid rock of a hill or mountain. Rock at *c* has been broken off by rain and frost and thrown down to foot of hill. Finest soil is being washed into stream to be carried away to build farms elsewhere.

In this latter case the soil may be very deep and mixed. we can now explain why the soil in some places is quite different in its nature from the rocks under it, and why there is such a variety in the the same locality and on the same farm. One field may be clayey, and across a stream we may find a sandy soil. They have come from different places, and have been washed down by the water and spread out at different times.

A step farther back can now be taken. We go to the hills, to

the great piles of rock. We observe that the old rock is weathered. If we break off a piece, the fresh surface shows a different appearance from the old weathered surface; it is generally harder.

We can rub off some of the old weathered surface; what we rub off is the weathered rock, fine sand or fine clay. We observe long cracks or crevices, some narrow and fine, some wide and deep. The rains find their way into these cracks and fill them up. Then winter comes on and the water in the cracks freezes. What will happen then? Just what happens when the barrel of rain water freezes, or the down pipes on the house freeze solid, or the bottles of canned fruit in the cellar freeze. There will be a bursting. And even though the quantity of water is small, it must expand, the rocks must give to make room for it. The cracks are made larger, a little of the surface is broken away, or a huge shoulder of the rock is burst off. Gradually, year by year, the rocks are broken up by the frost, the atmosphere wears them away, and the rains wash them down. The rocky cliffs are slowly broken down, and the ice, as it slowly moves down the sides of the mountain, scrapes and scratches off more and more. This material is washed away—the larger pieces but a short distance, the smaller pieces further, and the finest sand and clay carried far away, to be dropped or spread out somewhere to make soil. Seeds are dropped by the birds or blown by the winds; some plants sprout, grow, die, and decay and form a little humus. More plants grow and more humus is formed, until out of the material that came from the hard, rough rocks and the decay of roots and leaves a fine soil is formed, sandy in one place, clayey in another, and loamy in another.

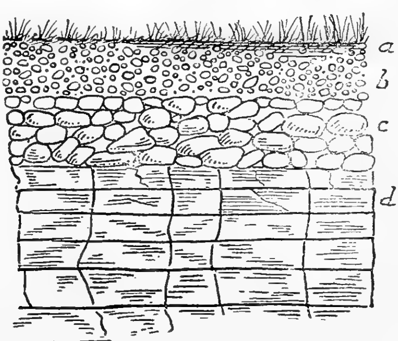



Figure 2.

**Soil formed from rock underneath.** *a* **soil with grass growing on it.** *b* **subsoil, coarser and more rocky.** *c* **coarse loose rocks.** *d* **rocks in layers, cracked.** *d* **changes to** *c*, *c* **changes to** *b* **and** *b* **to** *a*.

Conclusions:

1–All our soils have come from the breaking down of rocky material and the decay of former plants.

2–Soils may be classed as follows: sandy, clay, loam, and vegetable or humus soils.

3–The texture of the soil depends upon the amount of sand, clay, and humus mixed together forming it.

4–The nature of the soil depends to a large extent upon the nature of the rocks out of which the sand and the clay have been formed.

5–The rocks have been broken up by the action of the air, the freezing of the rain water in the rocks, the grinding of ice, and the down rush of rains and streams.

6–Some soils have been carried about from one place to another and spread out by the ice, snow, streams, and even to some extent by the wind.

7–Some soils have been formed out of the rocks beneath them, and from the decay of plants growing upon them.

8–Some soils, such as swamp soils, have been formed almost entirely from the decay of plants.

Suggestive:—

What class of plants are most useful in improving the soil, those with shallow growing roots or those having deep growing roots? Have you observed any difference between the roots of clover and the roots of timothy?

# CHAPTER III.

## HOW A PLANT GETS OUT OF THE SEED.

By L. H. Pammel.

The seed is the starting point of the individual in that great class of plants known as the Flowering Plants, represented by such common types as the pea, bean, corn, rose and cabbage.

I BEAN. A common garden bean may be obtained at any time. The seed is contained in a pod to which it is attached by a small seed stalk. The seed is smooth, usually longer than broad. There are many kinds of beans, the commonest bean is white, some beans are bluish black, others are spotted with brown, others are yellowish. You will observe that the seed lies on one side. Some beans are flattened on the two ends because they were packed so very closely in the pod that they touched each other.

You will observe that the two sides are much narrower than the middle. On one side is a prominent spot called the scar or hilum. Fig. 3. This is where the seed stalk was attached to the seed On one side of the scar you will notice a very small hole somewhat sunken in the bean, the micropyle. On the other end of the scar a pair of slightly elevated points. We will now soak the beans in water for half an hour. They have greatly changed in their outline. The beans are no longer smooth and even as they were when we first examined them. They are very much wrinkled. This wrinkled appearance is due to the water which they have taken up. We can now pull off the white covering or shell as it is commonly called. This white covering is known as the seed-coat or testa. The purpose of this coat is to protect the more delicate parts of the plant within. We shall look out for the little plant tucked away on the inside. We will now examine some beans which have been in water twelve hours. The beans are larger; they have taken up much more water. The ridge near the small opening on one edge of the seed scar is prominent. The seed coat should now be carefully removed. After the removal of the seed-coat two large

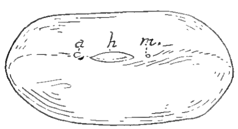



Figure 3.

Seed of bean, *h* hilum or seed scar, *m* micropyle. *a* two processes arillate.

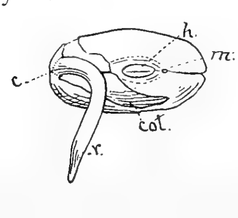



Figure 3.

Bean seed in process of germination. Testa or seed-coat broken, showing the cotyledons, *cot*. The hilum or scar where the seed was attached shown at *h*. The small opening in the testa, micropyle shown at *m*. At the base of the radicle, the caulicle.

fleshy bodies, the seed leaves or cotyledons, and a ridge may be made out. Now separate the seed leaves. At one end of the bean is a pointed body, the first root of the plant (or radicle), below it and connected with a pair of small leaves is the first stem (or caulicle). Fig. 3. The small leaves (or plumule) are snugly packed between the two seed leaves. Here, then, is the beginning of a plant.

2. PEA. We will now study the pea in the same way.

In the majority of cases the skin of the pea is roughened and close inspection will show an elongated body on one end of the seed, (the caulicle and radicle.) With a little magnifying lens you will be able to make out the elevated processes which have received the name of arillate processes as in the bean occurr on the other end of the hilum away from the micropyle. Fig. 4. The two cotyledons are round and fleshy, never elongated as in the bean. The plumule between the cotyledons consists of small scale- like leaves. Fig. 5 .

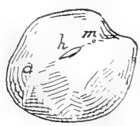



Figure 4.

**Seed of pea more or less wrinkled *h* hilum. *m* opening into seed. *a* small processes arillate.**

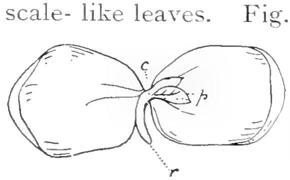



Figure 5.

**Seed of pea unfolded showing plumule *p*, and radicle *r*, and inital stem or caulicle at *c*.**

3. APPLE. Apples are easily obtained and are interesting objects for child study. The brown seeds of the apple are very different in shape to the pea or bean. Fig. 6. One end is pointed. The large end usually has a small beak like projection which is connected with a small ridge that comes from the base of the seed. You will observe that the seed is flat on one side and rounded on the other. Flattened on one side because each small compartment of the apple has two seeds which are pressed together. The small seed-scar occurs in a slight hollow at the pointed end of the seed. The covering of the seed (or seed coat) can be removed by carefully cutting the upper part of the seed-leaves. It can then be pulled off. You will notice that the coat can then be separated into two parts. The outer part is of a leathery nature and brown in color, the inner part is nearly colorless and not nearly so tough. The lower

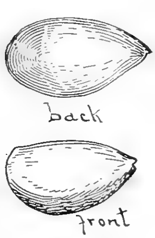



Figure 6.

**Seed of apple. the notch where it was attached.**


Figure 7.

Cotyledons of apple unfolded to show plumule *p* and radicle *r*.

part of the embryo has a small point which projects beyond the two seed-leaves. Fig. 7. This is a part of the initial stem, with the initial root at the other end. The plumule lies between the two seed-leaves at the other end of the caulicle, but this is very small.

4 SQUASH. The seeds of squash are flattened with a rim or border on the edges. The seeds are longer than broad, and the seed scar occurs in a depression at the small end of the seed. At the shorter end of the seed occurs a conspicuous opening. Cutting the seed lengthwise, this opening will be seen to extend for some little distance along the edges of the two seed-leaves. Now remove the white covering of the seed. Note that the outer is quite thick and somewhat brittle. The inner part is greenish and is closely attached to the seed-leaves. The small end of the two seed-leaves is pointed. Separate the two seed-leaves at the upper wide part of the seed, and notice that the two seed-leaves are fleshy and thick. The conical part occurs at the pointed end of the seed. This pointed end consists of the very short stem, the plumule between the seed leaves and at one side a small, fleshy outgrowth, the "pumpkin peg". We shall speak of this again.

HOW THE FOOD IS STORED.

In all of the above seeds the nourishing material is stored in the two fleshy seed-leaves. In the bean, pea, and apple this food consists of starch and albumen. Albumen is like the substance found in flesh. In the pumpkin this food consists of fat and albumen. This food is, of course, for the purpose of nourishing the young plant till it is able to take care of itself. In the next representative, maize, (corn) the greater part of the seed is made up of material stored in a special part of the embryo.

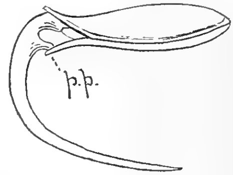



Figure 8.

Pumpkin seed in a process of germination.

5 MAIZE. There are many varieties of maize. These differ in shape, size and color. Sweet corn is much wrinkled when dry. In common dent the upper part of the kernel has a prominent groove, hence, the name dent. Our common pop corn is smooth. The little point at the side towards the groove may be made out. We shall now place our kernel in water for half an hour. Like the bean the surface soon becomes wrinkled because it has taken up some water. Leaving the kernel in water for a longer time the wrinkled appear-

ance disappears, it becomes swollen and much larger since much more water has been absorbed. We shall now remove the shell. At one side we note the yellowish, elongated body, the germ or embryo. Fig. 9. The other part of the seed is white and mealy. This is the endosperm. From this endosperm corn starch is made. This endosperm contains a nourishing substance which is used to assist the small embryo to grow. The small embryo may be removed. It will be found to consist of a single seed-leaf, the small initial root and stem, as well as a small plumule consisting of several very small leaves.

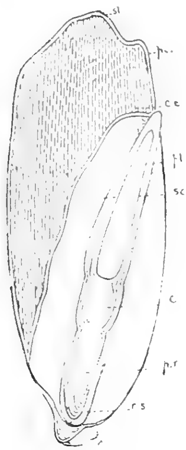


Figure 9.

**Section of corn showing embryo.** *p l* **young leaflet;** *p r* **young rootlet. Darkened portion is albumen.**

6. PEANUT. The peanut, though commonly called a nut, is not a nut but a pod. It belongs to the same family that the pea and bean do. While the seeds of the pea and bean are produced in a pod above the ground, those of the peanut are produced in a pod which matures in the soil. The peanut matures its seed in a rather interesting way. The flowers are born in the axles of the leaves close to the ground. After fertilization the stalk elongates and pushes the little pod into the soil. Here it developes and produces the pod so familiar to most persons. It is roughened, showing numerous veins on the outside and small depressions. On opening these pods you will find two or three or sometimes only one seed with a brown covering. The brown covering is the seed-coat or testa and is marked by several longitudinal deeper colored lines. On opening a seed one observes that it has a conspicuous plumule between the two cotyledons with a radicle extending beyond the latter. Fig. 10.

7. DATE PALM. The seed of tha date palm is rather easy to obtain and it is of interest because its reserve food is not starch, but fats and albuminoids, and a substance which is similar to vegetable ivory. The seed is extremely difficult to cut on this account. The seed is elongated with a

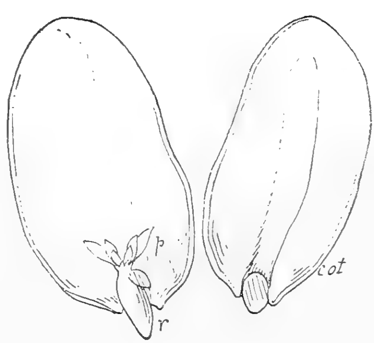



Figure 10.

**Embryo of peanut exposed showing two cotyledons,** *cot*; **the plumule,** *p*; **and the primary root or radicle,** *r*. **The caulicle or initial stem just below plumule.**

groove on one side. Fig. 11. A cross section made through the seed will show that it is in the form of a semi-circle. Fig. 12. Most of the seed is made up of the hard, horny albumen or endosperm. The small embryo is situated at one end of the seed.

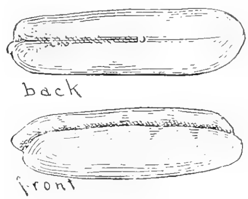



Figure 11

**Back and front view of date palm seed.**

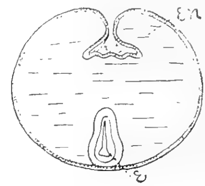



Figure 12.

**Cross section date palm seed The greater part of the seed is hard, horny endosperm albumen The embryo shown at e.**

8. FLAX SEED. This is flattened, much longer than broad, pointed at the lower end where the seed scar occurs. The seed is smooth and brown in color

Now moisten the seed with water; you will notice that it feels like mucilage. The outer part of the seed-coat has the property of swelling when water is added. We will cut the seed lengthwise; you will notice that the brown seed-coat has a light colored substance next to it; this is nourishing material stored outside of the embryo and has received the name of albumen or endosperm. This is similar to that found in maize, where it is mealy, only it is not so abundant. The embryo is situated in the center of the seed (Fig. 13) and consists of the two seed leaves called the cotyledons, and the conical initial stem and rootlet below, Fig. 14.

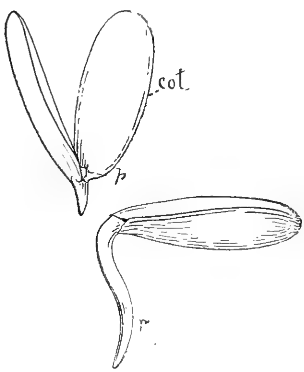



Figure 13.

**Flax with radicle or root *r*. In upper figure, *cot*, cotyledons or seed leaves and *p* plumule.**

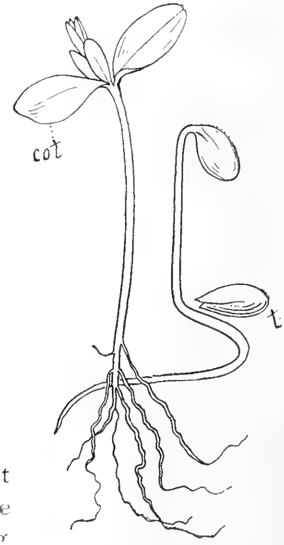



Figure 14.

**Flax seed in process of ger- *cot*, cotyledons, *t*, testa with cotyledon removed.**

9. BUCKWHEAT. The so called seed is not a seed but is made up of a pod with the seed closely united to the pod. This union is not as close as in the case of corn. It is not, however, a true pod. Buckwheat kernels are usually brownish in color, though some are gray. In our common buckwheat the kernel has three sharp ridges running from the broad base to the pointed tip. The sides are somewhat similar. In some cases you may be able to see three somewhat recurved affairs. Let us now remove the brown covering; underneath it you will observe a lighter colored part, the seed-coat. A small, yellowish brown, circular spot with a darker center occurs where the seed was attached to the brown hull. We will now cut the buckwheat kernels across near the base. Fig. 16. You will observe that most of the seed is made up of a white,. mealy substance the nourishing material consisting largely of starch for the young growing embryo. This is the endosperm. In this white mealy substance is a small, slender somewhat folded, thread-like body, the embryo.

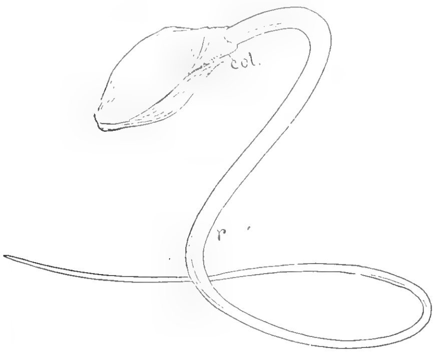



Figure 15.

Buckwheat in process of germinating. *r* radicle pushing its way out. The Cotyledons or seed leaves *cot.* still within coat.

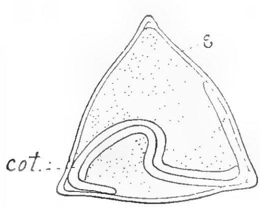



Figure 16.

Cross-section buckwheat, the dotted portion being endosperm or albumen which is food for the growing embryo which is folded inside.

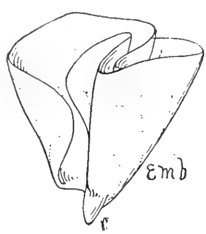



Figure 17.

Embryo of Buckwheat showing manner of folding in seed.

The seed leaves are very thin and folded and hence have the appearance of being thread-like in cross-section. Fig. 17.

10. CASTOR-OIL BEAN. The seed of castor-oil bean is the source from which oil is derived. The seed of our common variety is longer than broad, nearly oval, with a white fleshy outgrowth. At one side is a prominent ridge which divides the seed into two halves. On the lower side the seed is rounded out. The seeds of our common variety are smooth, shining, gray in color marked with brown spots. Fig 19. We will now cut the seed lengthwise; the hard, smooth testa is somewhat brittle. The bulk of the seed is made up of endosperm which is very oily, and contains an abundance of albumen. Starch is absent. The small embryo occurs in the endosperm. Fig. 20.

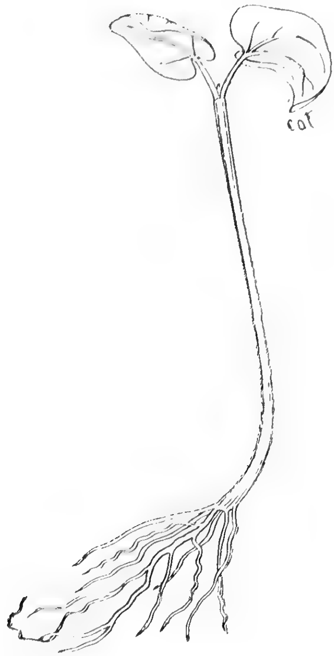



Figure 18.

**Buckwheat with two cotyledons or seed-leaves unfolded.**


Figure 19.

**Castor oil bean. The sculptured testa or seed coat. The caruncle shown at *car*.**

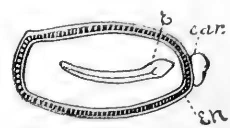



Figure 20.

**Cross-section se o castor oil bean. *e* elongated embryo surrounded by the endosperm and the seed coats on the outside, *e n*. The caruncle, *car*, an outgrowth over the hilum coming from the micropyle.**

## HOW PLANTS GERMINATE.

We shall now undertake to find out some simple things about the way plants germinate, and this can be done only by experimenting. This is the only way that we can acquire the information we want. For these purposes it will be neccessary for the teacher to get a box or pan three or four feet long, two feet wide and four inches deep. Fill this with three inches of sand, moisten and plant with two dozen beans and two dozen peas. The box should be kept at a comfortable temperature during the day,—a room in which child

ren are comfortable. At night the box should not be allowed to become cold as this will retard the germination. If the room becomes cold during the night protect the box by covering, or keep in a warm place. Watch changes from day to day and note when the first plants appear above the ground.

1. BEAN. The first thing observed in the bean is a small arch, neither the seed-coat or seed leaves can be seen, but a little later the large, fleshy seed-leaves partially show. In some cases the seed-coat may remain attached but generally this remains in the soil. As the young plant has pulled itself out of this protecting covering the seed-leaves and stem soon straighten up. The small, delicate plumule spoken of in connection with the seed is much longer and may be seen beyond the cotyledon. A little later the seed-leaves are pointed upward. The plumule consists of two expanded leaves and a bud at the base. If you will now carefully remove one of these seedlings from the soil the small root may be seen. Coming from this root are small fibers, the rootlets. At the end of the main root is a small point, the root-cap, free from sand. The root pushes its way through the soil by means of this cap. Growth, however, does not take place at the root-cap, but at a short distance back from the tip.

2. PEA. In germinating the pea behaves very different from the bean. The first thing observed is the arch, but the two seed-leaves remain in the ground. They do not perform the function of leaves as do the seed-leaves of the bean. The little plumule is arched till it is above the surface of the ground, when gradually it straightens out. The arch of the bean and pea protect the delicate structure of the plant. In an older pea plant small leaves or scales may be seen at the lower end near the ground. Further up the stem the leaves gradually become larger. An examination of an older plant with the seed still attached will show that the seed-leaves are withered. What has become of this material stored in the fleshy seed-leaves? It has been used as food by the growing plant. You will observe in peas which are beginning to germinate that a slender cylindrical body is making its way into the soil. This is the primary root. Fig. 21. It is not straight, but curved. If you will watch its

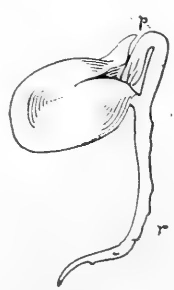



Figure 21.

Pea germinating, *r* radicle and plumule at *p*.

growth you can easily see that it goes first in one direction, then in another. Fig. 22. A little later several rootlets make their appearance. In other cases several small rootlets make their appearance close to where the primary root first appeared. Near the end of the primary root and the rootlets, very minute hairs can be made out; these are called root-hairs. The tip of the root, as in the bean does not contain these root hairs. This root-cap serves as in the bean, to guide the root in the soil.


Figure 22.

Pea in process of germination. *p* plumule. *r* radicle.

3. APPLE. The apple germinates much as the bean, but in this case the seeds require a long period of rest. The seeds will not germinate immediately when they are taken out of the apple in the fall. The teacher should put a lot of apple seeds in a box cover them with a little soil, place the box where it will not freeze or in a cellar. During the month of April these seeds may be planted as were the beans and peas. In the course of a week the seeds will germinate much as the bean. The two seed-leaves are pushed out of the soil and expand. The root pushes down into the soil. In a short time successive leaves are formed.


Figure 23.

Germinating pea after all the nourishment in the seed has been used. *l* leaf. *ten* tendril at the end of leaf which enables the plant to climb.

4. SQUASH. The seeds should be planted in a box of earth. In the course of two days an examination should be made of some of the seeds. If the conditions have been very favorable you will observe that the seed is

very much swollen and that where the seed-scar occurs the seed-coat is split. A day later a small root pushes its way out. As this root becomes longer you will notice a small projection, the squash peg, which was mentioned in connection with the seed. Fig. 24. In four days this root is much longer than the seed.

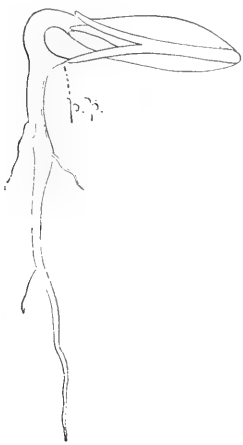



Figure 24.

**Pumpkin in process of germinating, trying to extricate itself from its seed-coats. *pp* pumpkin peg.**

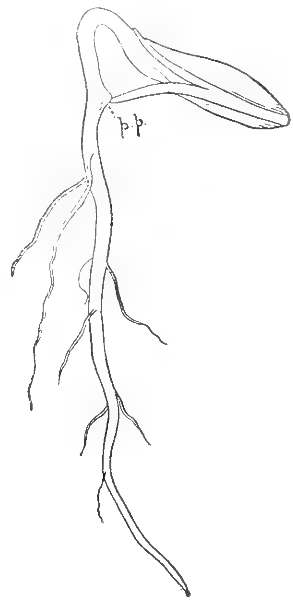



Figure 25.

**Pumpkin germinating showing more advanced stage. *pp* pumpkin peg.**

The seed-coat is forced apart, and "the seed leaves are trying to back out of the seed." The progressive changes should be carefully watched and drawn. The first root has produced smaller roots. Fig. 25. These push their way through the soil, now in one direction, then in another. If you will now examine the seeds which have not been disturbed you will notice the arch and a part of the two seed-leaves trying to push themselves above the ground. A little later they have succeeded, the small stem is curved, the two seed-leaves are horizontal with their ends partially spread apart. Let us wait a little longer. You will notice that the stem is slightly curved, the small leaves are straight. Fig. 26. The seed leaves gradually unfold and the little plumule may be seen. The first real leaf grows rapidly, followed by others.

Figure 26.

**Squash with two cotyledons. Seed leaves folded lengthwise.**

5. Maize. The embryo of corn is much more complex than the pea, bean, apple or squash. In a previous paragraph I called attention to the embryo with its single cotyledon, the large amount of food found in the mealy part of the maize which the embryo uses in its development. Maize kernels which have been placed in sand and kept in a warm place may be examined in forty-eight hours. The embryo is much larger than the dry grains because of the water it has taken up. The seed-leaf never leaves the kernel, but the plumule soon elongates in the presence of moisture and heat. The radicle at the lower end also elongates. A maize kernel three or four days in the soil shows a small projection. If this is carefully laid out the student will be able to see that the plumule consists of a succession of very small leaves in specimens that are well out of the ground. The small leaves have flattened out, the lower leaf is nothing but a scale, not green like the expanded leaf. Let us now examine some of the plants with good developed roots. Fig. 27. From the lower end of the

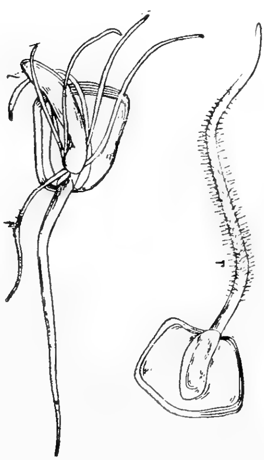


Figure 27.

**Germination of good seed. *r* primary root in figure to the right with root hairs. *r* secondary roots; *l* plumule.**

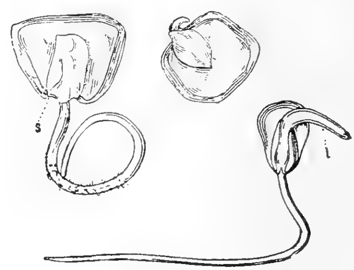


Figure 28.

**Seed with weak germination except pop corn on the right. *s* scutellum underneath; *l* plumule.**

root in the seed, numerous small fibrous roots may be seen. These produce other small rootlets. The root-cap may be seen at the tip, and back of it the small root-hairs which have fastened themselves to the soil particles, with a kind of mucilage they have formed. Let us examine other seedlings. You are sure to find some where roots come from the seed near the plumule.

In others, especially such as are germinated on moist paper,

the primary root becomes very long, containing few rootlets. The primary root is not straight, but bent first in one direction then in another. Fig. 28. If these seedlings are placed on moist sand, the top bends toward the ground and soon forces its way into the loose sand. Examine young corn plants two or three weeks old and you may be able to make out the first joint above the ground. Fig. 29. If you will watch the progress of these you can see small rootlets coming from this joint. A corn plant early begins to form its air roots. These roots are directed towards the earth. When they strike it, small root hairs and small rootlets are formed.

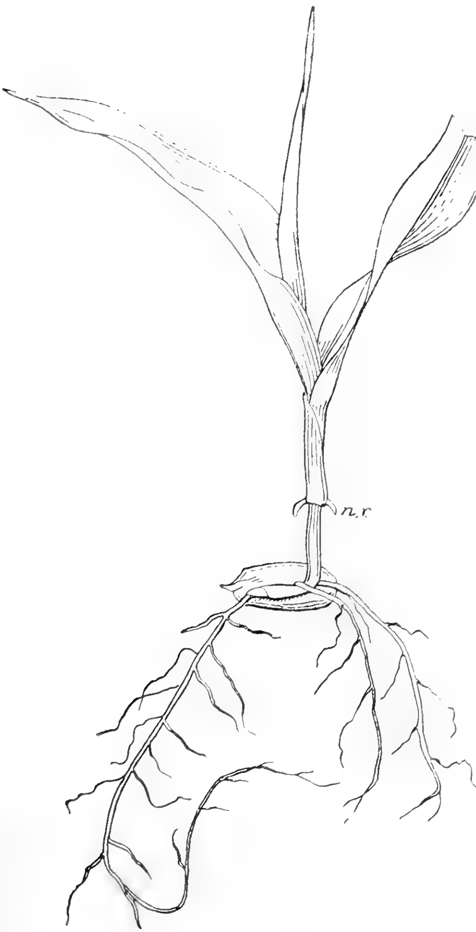



Figure 29.

Germinating corn. Nutritious material in seed ex- *n r* nodal roots.

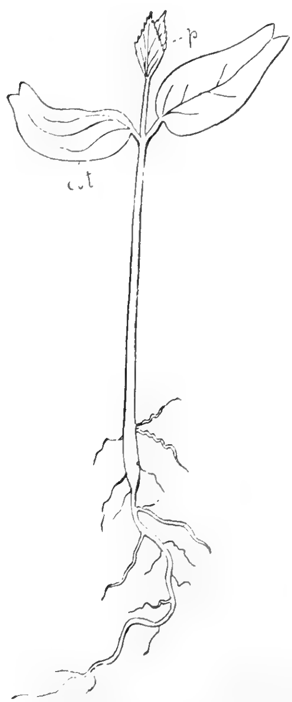



Figure 30.

Peanut in process of germination. *p* plumule; *cot* cotyledons.

6. MAPLES. The maples are very suggestive. Our common soft or silver maple drops its fruit during the month of May and who has not observed the keys of this fruit in a grassy lawn, with the heavy end sticking in the grass? The two fleshy seed leaves are broad and short, straight except a small fold near the top. They do not appear above the ground as is usual in other maples. The small root pushes its way into the soil while the small stem with its plumule rises above the ground where the small leaves unfold. The red maple and black maple have crumpled embryos with considerable development of caulicle. The black maple, which is not uncommon in this state, may be obtained in quantity during the month of May, showing all stages of germination. We observe that the black maple does not germinate till spring. The two cotyledons appear above the ground, the short stem below, the plumule elongates and soon produces fully developed leaves.

# CHAPTER IV.

## A SUGGESTIVE READING LESSON.

## SOME FEATURES OF PLANT GROWTH.

JAMES ATKINSON, Ames, Iowa.

With the exception of products of the sea the entire food supply for mankind is derived from the plant world. Whether it be breadstuffs or meats, they are alike the finished product of vegetation. Nature has made provision for the support of primitive man, but as civilization advances the art of man is used to multiply the products of vegetation, both in variety and quantity. It matters not whether our lot be cast in a great metropolis or on the prairie plains, our vital concern in the products of vegetation is the same and should be sufficient to stimulate us to acquire a knowledge of the habits of growing plants, and the characteristics of some of the world's staple crops.

ORGANS OF VEGETATION:—If a seed is placed in a soil under certain conditions of warmth and moisture, green leaves soon make their appearance above the ground while roots develop and penetrate the soil. These, together with the stem, constitute the organs of vegetation. It is our purpose to investigate some of the problems connected with the development of these organs.

COMPOSITION OF PLANTS. All plants are not alike in composition, but in a general way they are alike in being composed of water and dry matter. Nine-tenths of such crops as potatoes, turnips, and beets are composed of water.

To find out whether or not plants contain water, a simple experiment may be tried.

**Pull about a pound of green grass, weigh it carefully, then place it in an oven. Leave it there until it seems perfectly dry, then remove and weigh again. The loss in weight represents the amount of water the plant contains.**

WATER. From what source is this water obtained and of what value is it to a plant? As the roots penetrate the soil they constantly come in contact with a certain amount of water. Sometimes this is present in sufficient quantities to completely saturate the soil, while at other times the soil may scarcely be damp. It passes through the roots and stem and is evaporated from the surface of the leaves. In its passage through the plant it carries with it plant food from the soil, and also carries the food formed within the plant to where it is required.

Besides being a vehicle of food, it has other functions to perform. In the first place its passage from the cool soil into the

plant tends to regulate the temperature. Evaporation is a cooling process, and as this is constantly taking place from the surface it has much to do with keeping the plant cool in the presence of direct sunlight.

In order to prove that evaporation does take place from the surface of all green plants, take a quart or pint jar, remove the cover and place it, mouth downward over some green grass in the presence of sunlight. It will be found that moisture will collect in the inside of the jar in sufficient quantity to form large drops.

DRY MATTER. This is the part of the plant that remains after the water is driven off. It is composed of two parts, one of which is given off when the plant is burned, while the other remains behind in the form of ashes.

A very simple experiment will illustrate this point quite clearly.

Take the dry grass used in the previous experiment and place it in an iron vessel on a stove or in some way bring it in contact with a good fire. It will be found that only a small portion, the ash, remains.

We spoke about the source of water in plant life. We shall now enquire into the source from which the remaining substances were obtained. We are all well aware that the leaves of plants are constantly surrounded by atmospheric air. This air contains a substance known as Carbonic acid which is taken up by the leaves, of the plant and becomes part of the structure of the leaves, stem, and root. The carbon taken from this source forms about half of the dry matter of the plant. Oxygen, Nitrogen, and Hydrogen are other elements that enter into the composition of the part of the plant that burns. The first of these is taken partly from the soil, being contained in the water that surrounded the roots. The ash, or that portion of the plant remaining after burning, forms but a small portion of the entire plant. It is composed of iron, potash, lime, magnesium and phosphoric acid. These form, as it were, the frame work around which the whole fabric of the plant is constucted. They are usually present in soil water, and enter the plant through the medium of the roots. The presence or absence of these substances in suitable form constitutes the difference between a rich or poor soil.

From what has been said it will be observed that the food materials enter the plant in the form of a fluid, either a liquid as water, or a gas as carbonic acid and oxygen. It was long thought that small particles of the soil entered the roots, but it is now known that this is not the case.

Figure 31.

**Showing root growth of the corn plant.**

SEED PRODUCTION. The primary object of most farm crops is the production of seed. The corn plant is familiar to most of us, so we will use it to illustrate the process of seed production. During the first few weeks the energy of the plant is devoted to the production of leaves, roots, and stem. When these have attained a degree of maturity, there appears at the top of the stem, what is known as the tassel, which is indicated by the letter (a) in Figure 31. Midway between the root and the tassel appears the silk, indicated by the letter (c) in Figure 31. These constitute the flower of the corn plant. At a certain period in the development of these, there is given off a fine dust-like substance from the tassel. This is carried by the wind and brought in contact with the silk, which is composed of many threads. These little dust-like particles, or pollen grains, send out tubes which pass down the silk threads until they penetrate the body of the ear, (b) Figure 31. Here a union takes place, known as fertilization, which gives rise to a kernel of corn for every thread of silk. Figure 31, then, represents a partially matured ear showing how the silk threads are attached to the grains or kernels. In case of other cereals, such as wheat, oats or barley, fertilization is in no way dependent upon the wind, as both parts of the flower are within the same glume or chaff,

ROOTS. In discussing the habits of plants it would be a grave omission to omit their root development. It is the common belief of many persons that the roots of plants occupy only the first few inches of the surface soil. For the purpose of finding out the extent of root development, some corn and grass plants were taken from the soil with much care in order to avoid breaking the roots. Figure 31 shows two hills of corn that were taken from the soil and placed in a frame where the soil was afterwards washed from the roots. The cut shows the root development to a depth of fifty-six inches and even at this depth some of the roots were broken off, showing that they penetrate to a greater depth than this.

Figure 32 represents a bunch of Kentucky blue grass taken from the soil in the same manner, which shows the root development to a depth of three feet.

But such root development as is above described cannot take place unless the soil is in the proper condition, and without a perfect root system, plants cannot reach their fullest development. If the reader's interest has been aroused in this matter, it would be well to inquire into the various conditions of the soil which has so much to do with the perfect or imperfect development of plants.

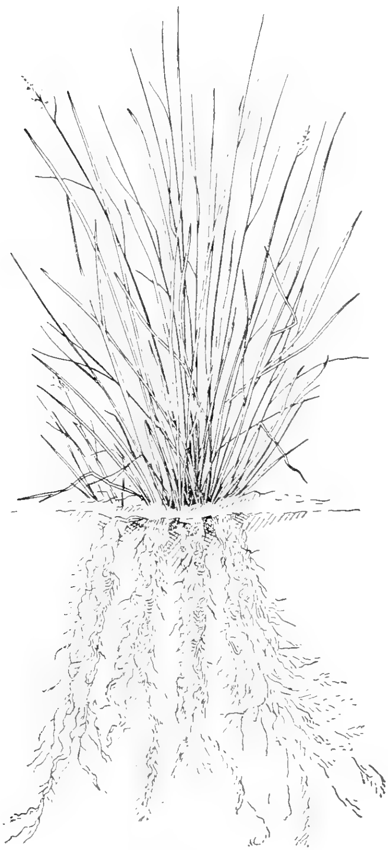


Fig III

Figure 32.

**How the roots of blue grass run down into the soil.**

# CHAPTER V.

## HOW TO OBSERVE INSECTS.

H. E. Summers, Ames, Iowa.

Insects, in consequence of their abundance, their convenient size, and the ease with which they may be kept alive in the school room, furnish perhaps the best material with which to begin the study of zoology with young pupils. They may be studied in many different ways, each of which will lead to the discovery of new facts concerning them and bring us nearer to a full knowledge of their relation to the entire living world. Their structure as illustrated in various selected forms may be investigated, and by a comparison of these forms the student will come to appreciate the meaning of homology, and when the reason for this homology is learned, to understand the principles in accordance with which animals are classified. Again, observation of the habits, especially of aquatic insects, furnish a never ending source of delight and instruction to children. Last to be here mentioned, their metamorphoses, or the transformations that they pass through before reaching the adult state, bring the pupil in contact with facts so wonderful that an interest is often aroused that lasts through life.

This paper is devoted to some hints on what and how to observe certain facts illustrating more particularly this last topic. And it should be fully understood that these suggestions are for the use of the teacher, not of the pupil. Most of what is here dogmatically stated, the teacher should, by judicious questioning, lead the pupils to discover for themselves.

Throughout the entire summer there may be seen flitting about in gardens, especially around the cabbage and other plants belonging to the mustard family, medium sized, white butterflies, usually with a few black spots, and often slightly tinged with yellow. There may be two different kinds of these; the one usually most common is known as the cabbage butterfly, the other as the checkered white. Figure 33. The former is the one here considered, although most of what is said applies equally well to the latter.

Figure 33

Checkered white, male. Checkered white, female.

Closely observed they will be seen to alight occasionally on a leaf, usually on the under side, and then to fly away to another plant. If the exact place on the leaf where one alights be carefully noted and then examined after the butterfly has departed, there will generally be found a single egg that has been attached there by the insect. This is of a light yellow color, and on examination with a lense is seen to be most beautifully and regularly marked with longitudinal ribs. If possible, the pupils should watch the butterflies laying their eggs in the field. In any case, there should be brought into the school-room, in a pot or box, one or more living cabbage plants on which eggs have been deposited.

In a few days there hatches from the egg a tiny, green, worm-like larva or caterpiller. Being possessed of a good appetite, it eats the shell from which it has just issued, and then attacks the substance of the cabbage. While small it can eat only the surface of the leaf, but it does this with such assiduity that it soon increases twenty fold in size, and is in a short time able to bite through the entire thickness of the leaf. It is especially active at night, eating then almost continuously, but in the day time it is satisfied with only an occasional meal. Between these periods of feasting it lies quietly stretched along a leaf vein of about its own diameter, and so exactly does its color resemble that of the cabbage that it is difficult for us to detect it. We can therefore understand that it commonly escapes the eyes of the birds that would think it a dainty morsel for themselves or their young.

As its body increases in size, its skin, unable to stretch much, becomes too small and the larva is obliged to shed it. As the time to molt approaches, the larva spins a carpet of silk on the leaf to give it a firm foot-hold and then becomes quiet. Its inaction is occasionlly interrupted by struggles intended to loosen from its body the skin it is about to cast. Finally the skin bursts open on the back and the insect struggles free from it. After making a meal off the cast skin it remains quiet for a time to give the new skin a chance to harden. It then begins to eat and grow until it is time for it to molt again. When it has grown to its full size, of about one and one half inches in length, it usually leaves the cabbage and seeks the underside of a board, fence rail, or other convenient object.

If observations are being carried on in the school-room, the plant on which the larvæ are feeding should be placed in a box with its front closed by mosquito netting before they have reached their full size; otherwise they are liable to wander so far as to be lost.

Having found an object from the underside of which it can suspend itself, it spins a band of silken threads crosswise under its back, attaching the band at each end to the object it is resting beneath. Figure 34. A silken pad is also spun at its tail end. It then sheds its skin in somewhat the same manner that has been described for its ordinary molts, but instead of simply a large larva coming forth, there appears a smooth, shiny object, without any external appendages, known as a pupa. During the process of shedding its larval skin, the tail end of the pupa is firmly attached to the silken pad already mentioned, and the silken loop extending crosswise under its back like a hammock suspends it with sufficient security.

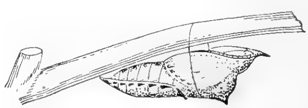


Figure 34.

Pupa of cabbage butterfly. after Scudder.

The pupa is incapable of any movement beyond a slight twitching when disturbed. The general color of the pupa is usually light gray but it varies often to yellowish green; numerous brownish dots are scattered over its surface.

The pupa state lasts, in summer, for from ten to twelve days. Its transparency is then seen to change somewhat, and soon after the skin bursts open on the back, and the adult butterfly, known

as an imago, issues. At first its wings are merely small soft pads, but if it has a free chance to crawl up some vertical surface they will be seen to grow to their full size in a very short time, and after a while to become dry and brittle. The butterfly is now ready to take flight, to seek its mate, and soon after, if a female, to lay its eggs on the cabbages for another generation.

Figure 35.

**Cabbage butterfiy--larva and imago.**

Three broods are usually produced in our northern states during the season. The larvæ of the last ones reach full size and change to pupæ in the autumn, whence issue the first brood of imagoes the following spring.

The danger to the larva of the cabbage butterfly from the attacks of birds has already been referred to. Birds, however, are not its only enemies. There are certain parasitic insects related to the bees and wasps that deposit their eggs on the butterfly larva soon after it hatches. The young of the parasite on hatching bore into the body of the butterfly larva and feed upon it until they reach maturity. As they are careful to avoid any of the vital organs of their host the latter does not die, but about the time that it should pupate there issues from its body a number of small larvæ which spin cocoons on its surface. In a few days there issues from these, adult parasites like those that laid their eggs on the butterfly larva. Besides these parasites and birds both the larva and imago are preyed upon by many other insects. A bacterial disease likewise attacks and oftens destroys the larva.

The transformation passed through by the butterfly in passing from the egg to the imago is such that none would suspect from an examination of the larvæ, pupa, and imago that they were different stages of the same insect. Insects in which the different stages are so entirely different are said to have a complete metamorphosis. Butterflies and moths both have a complete metamorphosis. In these the larva is commonly called a caterpillar. Two-winged flies, whose larvæ are maggots; beetles, whose larvæ are commonly called grubs, as well as bees and wasps all have a complete metamorphosis.

In certain other insects, however of which the grasshopper may furnish a typical example, (see next lesson) the insect that hatches from the egg is in general form similar to the adult. That is, it possesses six legs, antennæ, commonly called "horns," on its head and in a division of its body into head, thorax, and abdomen, is similar to the adult. The chief difference is that it lacks wings. A young insect that thus resembles its parent is called a nymph. As it grows it sheds its skin or molts at frequent intervals. At each molt it gradually becomes more and more like the adult in size and in the proportion of the different parts of its body. Finally at the last molt it changes into the imago.

Insects which thus resemble their parents in all stages from the egg upward are said to have an incomplete metamorphosis. Besides crickets, cock-roaches, and other forms related to the grasshopper the true bugs and some less well known insects have incomplete metamorphoses.

# CHAPTER VI.

## A NATURE STUDY LESSON ON THE GRASSHOPPER.

By JULIA E. ROGERS, East High School, Des Moines.

The day the fall term began the teacher asked the children to fetch in some live grasshoppers and put them into a cage that stood on her desk. It was a strange looking cage, and made in the following way: A strip of wire netting 36 inches long and 9 inches wide, was cut from an old screen door. This strip was bent so as to form the four sides of a nine inch cube. Two pieces each 9 inches square, were set in to form the top aud bottom. The corner seams were sewed with a wire thread over and over. A round hole two inches in diameter was cut in the top, and a three inch disc of cardboard formed the cover, held in place by a brass paper fastener. (The teacher and the little boy where she boarded made this cage on Saturday.)

The children came on the second morning and nearly all had "hoppers" to slip into the cage. There were several of the ordinary red legged variety, a few delicate-looking green ones, a big, striped fellow which looked muscular and pugnacious, and didn't like the cage at all. When the bell rang, and the opening exercises were over the following conversation took place:

"Did you have any trouble finding grasshoppers this morning?"

The tone and manner of the teacher were so pleasant and reassuring that the children were soon at their ease and ready to tell their experience. John was not shy, and the teacher said, nodding to him, "Tell us how you got the big one."

"He was in the road and I almost stepped on him. He made a loud snapping noise as he flew away and I lost him; he is just the color of the road. But I ran him down and caught him under my hat."

Mary. "I heard mine singing in the grass, and went up close, but it stopped. I looked a long time and at last it began again, and I saw it on a grass stem. It was just the same color. I grabbed it before it had time to get away, and brought it to school in my handkerchief."

Alice. "I got the brown one last night on our grape vine. It was hard to find, too, 'cause its the same color as the vine."

Jim. "I came acrost Gray's medder, and I found this fer yuh," and he laid in the teacher's hand a piece of sod in which was a large mass of eggs, cemented together, and packed away for safe keeping.

Tr. "Thank you, Jim, I didn't expect such good luck as to get eggs the first day. You may put these into the empty chalk box, and we will call it the incubator. It will be a very interesting box as the days go by."

Carl. "I got a lot off the corn leaves as I came through the field. They are the common kind with red legs, and not very big."

Tr. "I am going to keep these grasshoppers here all day, if I can make them comfortable. What can I do for them, John?"

John. "They want something to eat, I guess."

Alice. "Maybe they're thirsty."

Tr. "What would you suggest to feed them with, Arthur?"

Arthur. "They'll eat corn, or wheat or just anything green, I guess."

Tr. "Jim, you may go out and find something to feed the animals."

He goes and soon returns with a cabbage leaf dripping wet.

"I thought I might as well water 'em at the same time," he explains.

The leaf is poked in through the narrow door, and the children come up close to see the result. After a moment the insects begin to eat.

Tr. "I wish you would find out all you can in the next minute or two. The sharpest eyes will see the most, of course, let's see whose they are."

Time being called, the responses come thick and fast. The only rule is: "Don't interrupt any one who is speaking."

Carl. "Don't they work their mouths funny!"

Tr. "How, Carl?"

Carl. "Why, they chew up and down and sidewise all at once."

Mary. "And they have funny little fingers at the corners of their mouths."

Jim. "This one is eatin' right on the edge of the leaf."

Tom. "And he sticks his toes in to keep from falling off."

Alice. "They all nod their heads while they eat."

John. "They swell out their bodies about once a second. Is that the way they breathe, do you s'pose?"

Tr. "Watch them awhile, John, and think it over."

Ellen. "They have long horns on their heads, and they wave them up and down. Sometimes they lay them on the leaf."

Otto. "They have sharp teeth."

Arthur. "Yes, or they couldn't cut it off so clean and smooth, could they?"

Tr. "How many legs does the creature have?"

All. "Six."

Mary. "The hind pair are to jump with, so they're big and strong."

Tr. "How many wings?"

All. "Two!"

John. "There's four! That big grasshopper had a pair of black and yellow ones when he'd got up to fly. They must all be the same."

Tr. "Think about this a little longer, children. Get a grasshopper and ask him how many wings he has. He will tell you to look and see."

Carl. "Are those his eyes on the corners of his head?"

Tr. "Would that be a good place for eyes?"

Jim. "He could see in all directions. He wouldn't have to turn his head."

Alice. "The back part of the body is made of joints like a stove-pipe, only they move a little. And there are some dots on the sides."

Tr. "You have all been very good observers. I can't say who is best. I think we have stared at our visitors as long as we ought to today. You may write for your language lesson what you have learned about the grosshopper. You may find out all you can about the young ones tomorrow. Keep watch of the incubator and look for young ones out of doors. You will find their cast off clothing on the ground in grassy places, if you are patient and press the grass roots apart with care. Try to find out for sure how grasshoppers breathe; why they are so differently colored; and if they have the senses of sight, hearing, tou-h, taste, and smell. Mary and Alice may act as a Committee on Entertainment tomorrow, and see that there is no lack of food and water in the cage. Jim will watch events in the chalk box, and let us know the moment the first egg hatches. I have not answered questions for you because I wish you to work them out yourself, as you would an example in arithmetic. Next week, or perhaps before next week, we will talk over the new things we learn about the grasshopper,"

# CHAPTER VII.

## SCHOOL GARDENS.

By JOHN CRAIG, Ames, Iowa.

How often one sees a school house planted in the middle of a bare and unclothed piece of ground. No trees, shrubs or flowers to releave the barrenness and give a touch of civilization, life, and home-likeness. Why not undertake a small garden patch this year or next? It is astonishing how much pleasure and information may be derived from a strip of soil five by fifteen feet. It is remarkable how much horticultural knowledge may be stolen from it. Here seeds may be planted and watched as they sprout and spring into various forms. Here wild plants may be set and observed as they respond to improved conditions and better surroundings.

Where shall we establish the garden? In the center of the lot? I think not. Our tiny plot would be lost in such a position, besides running the risk of being trampled by the feet of play loving children. Where do flowers look best? Where a picture hangs to best advantage, against a suitable background. Then let us choose a sheltered corner by the schoolhouse, or a strip where we may have the friendly protection of a hedge row, or even the companionship of a fence. If our choice brings us alongside a fence, hedge, or walk where the bed can only be approached from one side, it should be quite narrow, not more than three feet wide.

THE FIRST THING TO DO: Get some of the larger boys interested, ask them to bring spades and then superintend the "digging bee." See that the grass and weed roots are all shaken out and thrown away or buried deep beneath the surface. At this point the teacher may start the children to thinking by askning the purpose of this mellowing and deepening process. How are soils formed? (See Chapter II.) Look for decaying weed and grass roots and show the changes going on which form soil out of the roots of clover and trees. Note how readily the water is absorbed by the loosened soil; the deeper it is loosened up, the more water it will hold. When the bed is thoroughly loosened up the next thing to be done is to rake the surface until the clods are all broken up perfectly fine and smooth.

This raking and fining of the surface is to hold the moisture. How is this done? By making the surface soil very fine. Notice soil in the school yard which has been undisturbed. It is hard,

has many cracks in it and is very dry. It has dried out—lost its moisture through these cracks and through many small openings. If these openings are covered the evaporation is arrested. We might accomplish this by covering the surface with straw or other mulching material; but we may do it much easier by keeping a thin, dry, dust covering which is secured by stirring the surface once or twice a week with a rake.

Our bed has been spaded and raked, what shall we put in it? Something that will grow quickly and give us plenty of flowers. We would suggest sweet peas first. They grow three or four feet high and should be placed in the background. The seeds are cheap and easily obtained. Plant them at least three inches deep. They should be put in early in the season—in the last week of April or the first week in May, before the corn planting time. Place the seeds an inch or two apart in the row and thin the plants when they come up so that they will stand four or five inches apart. They may either be planted in double rows six inches apart or in little clumps. Sweet peas have weak stems and should be given something to lean upon. Small branching limbs of trees will do very well stuck in the ground behind the rows or in the center of each cluster. It should not be imagined that one must use the rather unsightly brush to hold up the sweet peas. Wire netting does well, but this is more difficult to get and more costly to purchase. Anyhow sweet peas may be grown without either brush or wire netting. They take up a little more space if allowed to tumble about unsupported, but will give nearly as many flowers as if staked.

There are many kinds of sweet peas. A slight difference in the height of a plant or in the color of the flower allows the seedsman to call it a variety and give it a name. Sweet peas are sold in mixed packages which contain a variety of colors and in packages of a single color only. The single colors will be found more interesting. So let us buy some purples, lavenders, whites, pinks and yellows. Seedsmen's catalogues describe each variety so that selection is easy. Discuss the matter with the scholars, choose the variety and raise the money by taking up a collection. When the plants begin to flower remember that it is natnre's work to produce seed. If the flowers are picked off each day the plant keeps on trying to produce seed by growing more flowers, and thus the flowering season may be much extended.

So much for sweet peas. What else shall we grow? The sweet peas will furnish us an abundance of bloom during mid summer but begin to wane in September. Asters bloom best late

in summer so they ought to make a good second choice. There are tall growing asters and low growing kinds. The latter are called dwarfs on account of their small stature. A row of tall ones might be planted next to the sweet peas and a row of dwarfs next to them. In this way we may be able to see them all at a glance. Let us look at the aster seed; we find it very tiny compared to the fat sweet peas. If it were covered as deep it might not be able to push the young shoot through to the surface. We must therefore plant it very shallow—just covering it with soil well pressed down. Asters are sturdy little plants and need a good deal of elbow room. When they come up let us thin the tall ones to ten inches apart and the dwarfs to six inches. Let us put in two tall kinds and two dwarfs.

Shall we plant anything else? If we still have some space I would put in some pansies or phloxes. They will make a pretty edging and give lots of flowers. The seed may be covered about an inch deep and the plants thinned to six inches.

How many school teachers will try a garden next year? Write us for suggestions. We shall be glad to help you make your garden a success. If at any time the soil should be very dry, get the boys and girls to water the plants, but see that the wetting is very thorough, not merely on the surface. The watering should be done at night. Next morning the surface should be raked to prevent the dry air carrying off all the moisture and leaving the ground hard and baked.

C. S. G. C. Stuart Gager

# OUTLINE STUDY OF SEEDS AND SEEDLINGS

By Dr. C. STUART GAGER

[Reprinted from the Plant World, Volume 9, Number 9, September, 1906.]

# OUTLINE STUDY OF SEEDS AND SEEDLINGS.

By Dr. C. Stuart Gager,
*New York Botanical Garden.*

The following paragraphs were written for the use of the grade teachers in a city where school gardens had been introduced, and the work here outlined was correlated with the out-of-door work in the garden. The studies are only a suggestion as to the kind of work essential to secure the most desirable results from the work in the garden.

It is a great pity that so much school botany formerly considered the plant apart from the soil and air in which it grew. It were as great a pity to cultivate plants in the school garden without studying the elementary facts of physiology and ecology which are necessary to their intelligent care.

To make a successful garden one must know that the plants need to be a certain distance apart. But if the object of the school garden work is something more than merely to train gardeners, if it is to have sufficient educational value to justify the time it takes, then it becomes vitally important for the pupil to know why the plants must be a certain distance apart—to understand the fundamental needs and nature of the plant that make necessary all that he does in his garden.

While nature study is not a science, and while a course in nature study is non-scientific, it should never be unscientific in either its content or its method. Especially should the pupil begin here to acquire a scientific habit of thought and work. This aim is not antagonistic to the acquisition of a love of and sympathy with nature. Both objects should be attained if the subject is to justify its place in the course of study.

The surest foundation for the teacher, so far as plants are concerned, lies in a clear understanding of the principles of botany. The best preparation for teaching nature study is, not to have "taken" nature study one's self, but to have had thorough introductory laboratory courses in botany and zoology.

The outlines suggest a way to take up with grade pupils the topics indicated. The questions may either be asked of the class vocally, or each pupil may be supplied with a specimen and a mimeographed copy of the questions. Or the questions may be written on the blackboard. The main point is that the pupil shall proceed as independently as possible in his observing and thinking. The "Notes," of course, are for the teacher only.

About a week may profitably be spent on the structure of seeds. At the beginning of the study, seeds of the bean, pea, corn, squash, and castor-oil should be planted in boxes of soil after being soaked in water over night.

About three days before needed, seeds of the same kinds should be soaked over night and placed to germinate in moist sawdust, sphagnum, or between blotters.

## The Structure of the Bean Seed.

*Outside Parts.*

*Material.*—Three or four dry bean seeds for each pupil.

*Observation.*—Observe and describe the shape of the seeds. Are they all practically the same shape? Mow many times as long as broad? How many times as broad as thick? Make drawings four times as large as the seed to show the shape as seen from (*a*) the side, (*b*) the edge, (*c*) the end. Describe the color of the seed. Do you find any differences in color? If so, describe them. Observe a seed that has been soaked over night. Does it differ in any way from the dry seeds. If so, how? Do you find any parts or marks (besides differences in color) on the surface? If so, tell all you can about where they are, and their size and shapes. Make another drawing, enlarged four times, to show the parts you have observed. Write a paragraph telling clearly and accurately all you have learned about the structure of the bean seed.

*Note.*—This is not a memory exercise and the pupil should not be given any technical names of the structures observed. The aim is to teach the pupil to see the natural object *as it is,* and to describe it as seen in as clear and accurate a manner as possible. In the process the pupil acquires a knowledge of the seed struc-

ture, but this is of secondary importance. Nothing should be told by the teacher that can be found out by the child himself by observing the specimen.

He should have observed the *scar* (hilum), or place where the seed was fastened in the pod; the little hole, micropyle, at one side of the scar, and on the opposite side a small knob (strophiole), somewhat heart-shaped. (Oftentimes the ends of the seeds are somewhat flattened, due to crowding in the pod.)

Little is gained by giving the scientific terms. Not because they are hard (hilum is as easy as scar), but because they do not add at all to the clearness of the child's idea. Young pupils are apt to confuse ideas with their terms, and to think that they know a thing when they know only its name. The knowledge of scientific terms is an absolute hindrance to the child in an endeavor to describe.

*Inside Parts.*

*Material.*—Provide for each pupil, one soaked seed with the cotyledons carefully separated, the seed coat still adhering to the halves, and the hypocotyl and plumule still intact. Cut the skin so as not to injure any of the structures on the hilum edge.

*Observation.*—Observe the half of the seed to which the peg is not attached. Is the bean covered with a skin or *seed-coat?* Is this coat tough or very delicate? Is the coloring of the seed *on* the coat or *under* it? Is the inner surface of this half flat or cup-like? Is the surface of the other half the same? Can you think of any reason why the cup shape is a better one for the seed than a flat surface would be? Was this half attached to the other in any way? If it was, describe where. On the other half, do the knob, scar, and little hole belong to the seed-coat, or to the parts under the seed-coat? Is the peg straight or curved? What part of the seed-coat is over the *tip* of the peg? Is this the same in all bean seeds? What is on the opposite end of the peg from the pointed end? Is it composed of parts? If so, how many? What is their color? Are they in a straight line with the peg, or do they make a curve with it? Is the peg attached to this half of the bean? Can you see any signs of its having been attached to the other half? Make drawings (X4) showing

(1) the halves of the seeds as they were placed at first, only with the seed-coat removed; (2) only the peg with the leaves attached. Write a paragraph describing all you have learned concerning the inner parts of the bean seed.

*Note.*—This exercise teaches the importance of little things and the need of care and accuracy. The pupil should be made to feel that the bean seed must not be handled carelessly or picked to pieces merely because it is a common object. The children must not be permitted to poke the specimen with pencils, knives or pins.

Insist that the drawings be enlarged by the amounts indicated. Allow no shading. Every line in the drawing must represent some structure of the seed.

The pupil should have observed:

1. The relatively tough character of the seed-coat. 2. The fact that all the external features belong to the seed-coat. 3. The more or less *concave* inner surfaces of the two halves of the seed, giving room for the *peg and especially for the tender leaves at its end.* 4. The position of the tip of the peg *always directly under the little opening or hole.* 5. The peg curved and the leaves at the end making a little arch with the peg. The attachment of the peg to both halves of the seed. 6. The leaves, two in number, and folded one within the other.

Each half of the bean seed being roughly cup-shaped is termed a *cotyledon* (little cup). The leaves at the end of the peg form the *plumule.*

## The Structure of the Pea Seed.

With this exercise the teacher will doubtless meet such questions as: "What ought I to find?" "Ought there to be a little knob on the pea seed?" etc. The treatment of such questions in observational work marks the difference between the wise and the foolish teacher. In observation it is not a question of "ought," but a question of fact. Not "ought" there to be a little knob, but *is* there one.

This point is dwelt on because there is none more important in observational science than this. From the standpoint of *educa-*

*tion* it means acquiring the habit of independent thought and work, or else a blind, unintelligent following of authority. From the standpoint of *science*, it means valuing facts as they are, above preconceived notions of things as we imagine they are or ought to be. From the standpoint of *knowledge*, it means clear cut ideas obtained at first hand, instead of vague indefinite notions secured at second hand.

From this study of the outside of the pea seed, the pupil will learn its globular shape, the absence of the little knob (strophiole), and the possession, in common with the bean seed, of the scar and little opening. Usually some indication of the peg shows through the seed coat. If so, pupils should determine for themselves whether the little hole is directly over the tip of the peg.

A study of the inside of the pea seed, made as directed above for the bean seed, will show the tough seed-coat, the peg, fatter than in the bean seed, not as long, and not curved so much.

The pupil will observe the much swollen plumule here, also, not in a straight line with the peg, but making an arch with the latter. Are the cotyledons cup-shaped?

Drawings (X4) should be made of one view of the outside, showing the scar, little opening, and peg (if it shows through the coat); of the inside, similar to the one made of the bean seed.

In what ways are the bean seed and the pea seed alike? In what ways do they differ?

Write a paragraph telling all you have learned about the pea seed, and another paragraph telling all the ways in which the two seeds are alike and in what ways they are different.

### The Castor-Oil Seed.

The knob at the end is similar to the little knob on the bean seed. Here it is much larger and fleshier, and it is directly over the little opening which may be seen extending down through it. The scar is not prominent, but is close up under one side of the knob.

Make drawings (X4), one showing the seed as seen from the side, another to show the end view with the knob (here called the *caruncle*). Do not give the pupils the term.

The study of the internal structure of the seed is very difficult for young pupils. The teacher should have several well-soaked seeds dissected to show the pupils, and plain drawings on the board. Call attention to the hard brittle seed-coat.

Notice the short, straight peg. The fleshy halves of the seed are not cotyledons, but food for the young plant. This may be very carefully removed, showing the white, leaf-like, delicate cotyledons. The plumule is too small to be easily seen.

## Germination.

*Material.*—In boxes of convenient size, containing garden soil or, preferably, clean sand, plant six or eight seeds of the common white bean, the pea, corn, squash, having first soaked the seeds for twenty-four hours. Plant about a week before the study of how they break through the soil is taken up.

The successive steps in germination may best be followed by allowing seeds to germinate behind glass. For this purpose, line a Wellsbach chimney with a tube of blotting paper, setting the end of the chimney in sand or soil in a flower pot or box, and fill the chimney with moist saw-dust to keep the blotter close to the glass. (If this device is not convenient, an ordinary tumbler may be used. The shallowness of the tumbler, however, does not permit of very extensive root development.)

Have the children place five or six seeds of each kind mentioned above in water to soak over night. On the following day the pupils will observe that all the seeds have swollen. *This is the first step in germination* and the point should be made at this time.

Now place these seeds between the blotters and the glass so that they may be seen, and placed so that the tip of the peg of some of the seeds points vertically downward, of others upward, and of still others horizontally. Be sure that the corn grain is placed with the embryo side next the glass. Keep the seeds moist but not immersed in water, and, if possible, put in a dark place to develop. Lead the children to see that this would be best by questioning them concerning the light conditions under which the seed germinates naturally in soil.

*Observation.*—What part of the seed first breaks through the seed-coat? Is this the same for all the seeds? Is it better for the root to grow first? Would it not be just as well if the stem and leaves came out before the root grew? Why?

Do you see any special growth on the peg of the squash seed that helps the young squash plant get out of the seed-coat?

Does more than one root come through at first? Is this the same in all the seeds? In what direction does the first root (or roots) grow? Does the root grow downward in the seeds where the peg was placed horizontally or pointing vertically upwards? Would it not be just as well if the roots grew vertically upwards or sideways? Why?

Would the gardener's or farmer's work be any different if roots did not always grow downward in germination? Explain how.

After a time does the root begin to branch? If so, in what direction do these side roots grow? Would it not be better if they grew directly downward just as the first root grows? Why?

Can you see any fine white hairs (root-hairs) growing on the surface of the root? If so, do they cover all the root? Do they grow up to the very tip? What do you think they are for?

What part of the seed first appears above ground? Does this part appear before or after the branch roots have begun to grow? Is this the same in all the plants?

Drawings and written descriptions as above.

*Note.*—In these exercises the pupil begins to study the plant in action. It is doing something. The value, as in the study of seeds, consists in practice in observation, expression, and interpretation. That the first root grows vertically downward is a fact worth knowing. It is of infinitely more value to have reasoned out, even in the most elementary manner, the meaning and significance of this. Here, also, is emphasized the fact that observation is something more than merely looking at an object. It implies an active attitude on the part of the pupil in which *definite questions are put and their answers sought in the objects studied.*

Besides the educational discipline secured, the pupil will learn the following facts:

In the germination of a seed, the first part to begin growth is the root. The squash plant is helped out of the seed-coat by means of a little knob. One root only always appears first, and no matter in what position the seed lies, the root will take a course vertically downward. After the appearance of the main (or tap) root, the stem begins to grow. Branch roots do not grow downward like the main root, but more nearly horizontal. The root is covered in a definite region with numerous root hairs, which never extend quite to the tip of the root.

By careful questioning on the part of the teacher, the pupil should be taught that the greatest need of the plant is water, that the most abundant supply is in the soil, and that the plant needs to be held fast where it can get water. Therefore, the best good of the plant makes it necessary for the root to grow downward, first to hold the plant fast, second to absorb water for the plant. If the root did not grow downward (curving when necessary) no matter in what position the seed is placed, then gardeners and farmers would have laboriously to plant every seed root downward or else many would perish on germination.

By growing laterally, the branch (secondary) roots hold the plant more firmly in the soil, and at the same time enable the plant to secure water from a wider area.

The fine white root-hairs are parts of the root by which it absorbs the water from the soil. If they grew at the very tip of the root, they would be liable to injury, as the root pushed its way through the soil during growth.

### How the Stem Lifts Itself into the Air.

Watch carefully for the first signs of the planted seeds breaking the surface of the soil. How does the bean seedling break the ground? Does the *tip* of the stem appear first? Do all the different seeds planted break through the soil in the same way? Describe. Do all the seeds of the same kind break the ground in the same manner?

Rule a horizontal line across a sheet of pad paper to represent the surface of the soil, and at the left make a drawing to show how the bean seedling breaks through the ground. Save the

space at the right for the successive stages of growth and begin similar records for the pea, corn and squash.

Observe from day to day the different stages by which the stem becomes erect in the air, and represent them, as observed, in a row from left to right along the soil line as directed above. Represent five stages in each plant. Are the halves of the seed raised into the air in any of the plants? Written description as above.

*Note.*—It is best not to try to explain *why* some plants break through the soil in the form of an arch, while others do not, or why some lift the halves of the seed, while others do not. It is doubtful if the true significance of the fact is known, and a child is too young to discuss theories.

## THE PARTS OF THE PLANT.

*Material.*—Young seedlings of the common white bean, 5–6 inches high. (Any other variety will do.) The plant will be cleaner to handle if grown in moist sawdust instead of soil. Carefully remove the plants and clean the roots in water. It will be desirable also to have a plant or two grown in soil or sand for the purpose of showing how closely the soil clings to the roots.

*Observation.*—Can you easily distinguish the underground portion, *the root,* from above-ground portion, *the shoot?* How can you tell them apart? What part of the embryo has grown into the shoot? Can you recognize the plumule in the seedling? Have any of the parts changed color since leaving the seed-coat? If so, what parts and how have they changed?

*The Root.*—Is there a main *tap root?* Is the root branched? Which is longer, the root or the shoot? Which is the more branched? Do you think this is an advantage to the plant? How? What might be the result if the young shoot should branch more than the root? Does the soil cling very closely to the roots? What advantages result to the plant from the branching of the root?

*The Shoot.*—Observe that the shoot is composed of the stem and the leaves. Does the stem have branches? If so, describe. Are the leaves opposite each other on the stem? If not, describe how they occur. What do you find at the tip of the shoot? If

the cotyledons are raised above the soil, describe any changes you can see in their appearance. Are they opposite each other? Is the stem any bigger below the cotyledons than above them? Are there any leaves below the cotyledons? Do the cotyledons begin to shrivel up? What do you think makes them do so?

*The Leaves.*—Observe the first leaves above the cotyledons. Is there is a distinct *leaf stalk* and a broad, thin, flat *blade?* Do you find any *swelling* at any place on the leaf stalk? If so, where? If possible examine plants that have grown in a window. Have the leaves turned toward the light? If so, where did the bending take place? The tip of the blade is the *apex,* the place where the blade joins the leaf stalk is the *base* of the blade? Can you find two little wing-like parts on the leaf stalk at the base of the blade? Are there any where the leaf joins the stem? Is there a *joint* in the leaf stalk at this place?

Does the stalk extend up through the blade toward the apex, forming a *midrib?* Does the midrib branch into *veins?* Can you see an unbroken line of vein extending around the blade parallel to its edge? Of what advantage is this to the leaf? How can you tell the upper from the under side of the blade? What purposes do you think the veins serve? Are the two opposite first leaves alike? Make labeled drawings.

The other leaves above the first pair are *compound* leaves How many blades has each? Each of these blades is a *leaflet.* Has each leaflet a stalk? Is there a joint where each leaflet joins the leaf stalk? Does each leaflet have a pair of little leaf-like bodies near the base of its blade? Is there a pair also where the stalk joins the stem? Is there a joint in the stalk at this place? Are the stalks of the lower leaves longer or shorter than those of the upper ones? If the lower stalks were shorter could the lower blades get the sunlight as well? If the upper blades were not divided into three leaflets, would they shade the lower leaves more than now? Make labeled drawings and write descriptions.

The cotyledons have shrivelled because the food that made them thick has gone to nourish and feed the growing seedling. The first leaf of the bean is not a true simple leaf. It is what is known as *a unifoliate compound* leaf, that is, a compound leaf with only

one leaflet. This is shown in part by the joint at the base of the blade, and by the wing-like outgrowths (*stiples*). These outgrowths are seen at the base of the blade of each leaflet in the other leaves. The similar outgrowths at the base of the stalk are *stipules.* Elongation of the lower leaf stalks carries the blade out from under the upper leaves so that it gets better sunlight than it otherwise would. To observe this fact and reason out the meaning is more important than to learn the name of the stalk (*petiole*). The leaves above the first pair are *trifoliate compound leaves.* This branching of the blade permits more sunlight to penetrate to the lower leaves. To recognize this fact is more important than to learn that the leaves are *pinnately compound.*

This work gives a basis for the study of any other plant in the garden. It shows the *kind of facts* to look for and question about. All other plants in the school garden will be seen to be modifications, more or less profound, of the bean type.

# The Evergreens

## Methods of Study in Public School

## A Home Teacher

By C. M. WEED, under the Direction of
F. W. RANE, State Forester, State House
Boston, Mass., U. S. A.

# THE

# STUDY OF THE EVERGREENS

IN THE

# PUBLIC SCHOOLS.

PREPARED BY
CLARENCE M. WEED,
UNDER THE DIRECTION OF
F. W. RANE, STATE FORESTER.



BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1908.

Approved by

The State Board of Publication.

# PURPOSE.

This publication is offered by the State Forester as supplementary to "The Study of Trees in Our Primary Schools," issued by this office last year.

The coniferous or evergreen trees make an interesting group to study by themselves. They can be utilized by the teacher in the winter time, or dormant season of the year, when other material is not so accessible. In fact, at this season of the year they give great variety and beauty to the landscape. The interest in and association with the evergreens become very pronounced as soon as the deciduous tree leaves have changed from their natural beauty of summer to their grand autumnal glory, and finally fallen to the ground. The uses to which the evergreens are put at yuletide, and their part in making this season of the year one of the happiest to the child mind, make this the psychological time for their study.

If this treatise helps to awaken in our young and coming generation a greater interest and love in trees and nature it will have done its part.

Two other publications that teachers may find of assistance, if they do not possess them already, are: —

"The Commercial Forest Trees of Massachusetts. How you may know them. A Pocket Manual," for general use.

"The Study of Trees in Our Primary Schools," for teachers, mothers, and all interested in teaching children to love trees and nature.

Under the Resolves of 1908, chapter 121, the Governor and Council have designated that these publications be sold by the State Forester at a price not less than the cost thereof; and additional copies may be printed, the expense thereof to be paid from the receipt of such sales.

According to this decision the above-named publications are offered at the following prices: —

"The Commercial Forest Trees of Massachusetts. How you may know them. A Pocket Manual," for five cents a copy at this office, or by mail for two cents extra.

"The Study of Trees in Our Primary Schools," for twelve cents, or by mail eight cents extra.

In case a large number is wanted, as for schools, etc., they can be forwarded by express.

These publications are neatly gotten up, and as they are in great demand (the first edition of 5,000 having been exhausted in ten days), charging for them at cost is the only feasible method of dissemination.

ACKNOWLEDGMENTS.

Dr. Clarence Moores Weed, of the Lowell State Normal School, was selected to prepare this pamphlet. Owing to Professor Weed's knowledge and interest in public school work, he requires no introduction to Massachusetts teachers. In fact, the syllabus and suggestions herein given have passed the experimental stage, and have been successfully taught as outlined.

The illustrations are from prints and drawings by pupils in the Lowell Normal School and its training schools.

F. W. RANE,
*State Forester.*

STATE HOUSE, BOSTON, MASS.,
Oct. 1, 1908.

The ear shares with the eye the beautiful effects of weather on the landscape. The rushing of the storm through the narrow valley, the murmuring tremor of the pines in the gentle breeze, the rustling and bowing of a field of corn in an August gale, the clatter of palmettos in a wind, the rattle of pebbles on a beach, dragged down by the retiring wave, the onset of a thunder shower, — are delights for the ear as well as the eye. — CHARLES W. ELIOT.

# THE CONIFEROUS EVERGREENS.

The study of the coniferous evergreens is especially desirable early in winter, and for the lower grades may well culminate at the time of the holiday festivities.

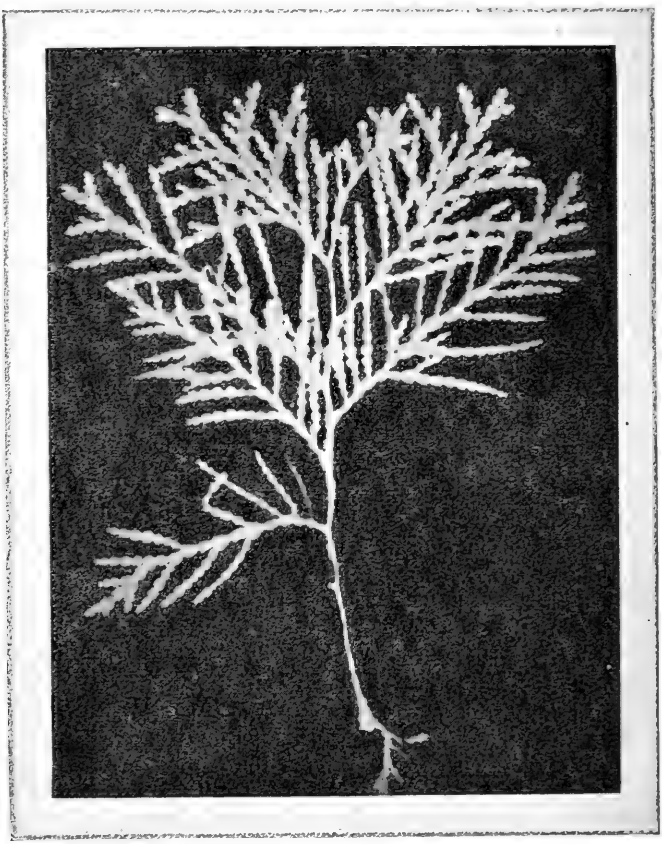
These trees furnish the most important features of many of our winter landscapes; they are of great beauty as well as of much economic value, and they give excellent opportunities for studies of distinctive educational worth. Their branches are easily obtained, and when brought into the schoolroom are of decided decorative value. They may be studied to great advantage in winter as they are available at a time when it is most difficult to get material for nature studies.

In this study of the evergreens especial emphasis should be placed upon the native species. These are to be found in fields and woods, where specimens may be gathered in abundance. A very large proportion of the conifers planted for ornamental purposes are exotic species, the determination of which is frequently difficult, and which have not the interest and associations possessed by the native sorts. An exception, however, must be made in the case of the Norway spruce, which has been so generally planted for so long a period that it is as abundant and as widely distributed as some of our native trees.

In associating the evergreens with the animal life of the winter season, the skillful teacher will point out the utility of their seeds as food for the winter birds, and the great benefit of their protection as homes, not only for the birds but for rabbits and other animals that require shelter during the winter months. The value to the trees themselves of their slender leaves in shedding snow will of course be pointed out.

In most localities it is a comparatively easy matter to get abundant material for the study of the evergreens. This is

one reason why the subject should be reserved for the winter season. Two or three small branches will furnish enough leaves of a given species to suffice for a whole class, and wherever there are large bearing trees, with little trouble one



ARBOR VITAE

can get the cones which are so necessary to an adequate study of these trees. The cones of the white pine may generally be found in abundance underneath the trees, while those of the pitch pine, though generally less numerous on the ground, are frequently within easy reach upon the lower branches. By a little searching one may often find trees which have

been blown over or cut down, so that the cones in the topmost branches may easily be reached. This applies not only to the pines but also to most of the conifers.

The cones of some of the spruces fall to the ground early, where they may readily be gathered. This is particularly true of the Norway spruce, the large and beautiful cones of which furnish most interesting objects for study. In the case of the black spruce, which abounds in peat bogs, the cones are generally within reach upon the smaller trees; this is also commonly true of the hemlock, the arbor vitæ and the tamarack or American larch. The curious berry-like fruits of the red juniper and the low juniper are also very easy to obtain.

The teacher who does not avail herself of the opportunity to make the collecting of these evergreens the object of many winter walks will miss a personal pleasure, and will not secure the enthusiasm from her pupils that she might easily get.

In the cities one can often obtain fir balsam and some of the spruces at Christmas time among the trees offered for sale as Christmas trees. It will frequently happen that such trees may be obtained directly from the pupils after the Christmas season is over.

In the hot, dry rooms of most schools the spruces, hemlock and other conifers whose leaves are shed in drying dry out rapidly and fall off, and may cause trouble for the janitors. This may be avoided to a considerable extent by keeping the specimens in unheated closets, or hanging them out of doors, when not in use; they will thus retain their leaves much longer.

## Methods of Study.

The teacher who appreciates the value of visual impressions in nature study will display before the pupils twigs and cones of the pines, and such other conifers as do not drop their leaves in drying, mounted upon good-sized sheets of paper or cardboard and plainly labelled. She will also make upon the blackboard characteristic drawings of the various species studied, using as far as possible colored

crayons, showing the appearance of cones and branches, as well as detail drawings of the leaves upon a larger scale.

The evergreens may be used to great advantage in bringing the pupils into direct contact with real things in nature. The material is so easily obtained, and in such abundance, that there is no excuse for adopting the mere question and answer method in vogue in many of our schools. Give the pupils twigs, or at least bundles of leaves, and if possible cones, and let them use their discriminating powers in sorting the specimens as to species. Let them see for themselves the distinctive characters of each, and in the higher grades let them determine the species by reference to illustrated tree books. Then let them make careful drawings of the twigs or leaves and cones of each species, being sure that they know the name while they are making the drawings. Part of the drawings at least should be made with a lead pencil, securing as great a degree of accuracy as is possible, but some of them should be made with green and brown pencil crayons, by means of which very attractive pictures may be obtained. In the upper grades it may also be worth while to use water colors for some of the drawings.

The importance of blackboard drawings by the pupils, especially in the grades above the fourth, can hardly be overestimated. These are especially valuable for the memory drawing, and in the case of the evergreens, through the use of green and brown crayons, the great advantage of colors that simulate the actual plants may be utilized.

Very beautiful Van Dyke solar prints may be made of many of the evergreens. Examples are shown in the accompanying illustrations of the arbor vitæ and the white pine.

In addition to the drawings the pupils may use the same specimens for language work, which shall take the form of short essays in which the chief characteristics of the specimens are described. The length and completeness of these descriptions will of course vary with the development of the pupil, but something worth while may be done in any grade above the fourth. These written exercises should be upon paper the same size as the drawing paper. Dictation exercises may also be given, using poems and prose selections treating of the various evergreens.

For the written descriptive exercises the pupil in the intermediate and upper grades should have before him upon the blackboard some such outline as the following. The wise teacher will of course adapt it to the degree of development of her pupils, leaving out those things which the pupil will be unable to describe to advantage. If there are no cones it may be better to omit that topic.

*Outline for Description of a Conifer.*

1. Leaf:—
   - Arrangement.
   - Color.
   - Length.
   - Shape.
   - Apex.
2. Bark:—
   - Color.
   - Surface.
3. Buds:—
   - Color.
   - Shape.
   - Surface.
4. Fruit:—
   - Color.
   - Size.
   - Shape.
   - Scales.
   - Seed.
5. Tree:—
   - Manner of growth.
   - Range.

Many of the conifers have distinctive odors, which may well be noted in their study. The aromatic perfume of the arbor vitæ is very different from the resinous odor of many of the pines, and would serve to identify it at any time.

Upon the foundation laid by the studies thus outlined a more complete superstructure may be built by a study of the trees out of doors, beginning with such as may be seen from the windows of the schoolroom, and continuing as far as possible by means of outdoor excursions. Occasional reviews with actual specimens, and memory drawings of leaves and cones, as well as sketches of the growing trees, will be helpful in making permanent the pupils' knowledge of the evergreens.

The final visible result of the pupils' work may be a booklet, into which is bound the drawings, the mounted specimens, the descriptions and the written selections. The completeness of these booklets and the perfection of their work will depend, of course, upon the development of the pupil and the kind of supervision given. To some extent such booklets

may be made in every grade of the lower schools, and they certainly may be made to great advantage in the high and normal schools. Some standard size of drawing paper, which is of good shape for artistic results, should be selected. A good size is six by nine inches, as this enables one to put both the mounted specimen and the drawing upon the same sheet if desired. To accompany the drawing paper there should be sheets of writing paper of the same size, ruled or unruled, as the development of the pupils may necessitate. All the sheets are to be punched upon the left-hand six-inch margin, so that they may be bound in covers of stiffer paper, either by the ordinary brass fasteners or preferably by means of raffia. In the latter case it is desirable that three holes be punched in the margin.

### Examinations.

It is very easy to determine whether the pupils know the evergreens they have been studying or not. Place a small branch and cone of each variety upon a side table, numbering each species, and let the pupil, absolutely without assistance, make a list of the names of the evergreens represented. Memory drawings may also be utilized for examinations, or the pupils may be required to write a synopsis of the distinctive characteristics of a certain number of species.

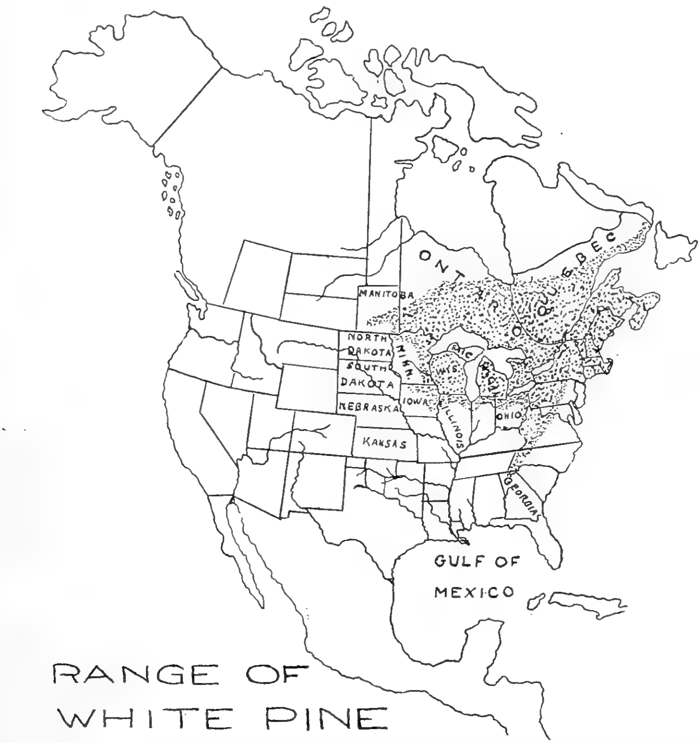
### Correlations.

It may be worth while, at the risk of some repetition, to indicate briefly the correlations with other studies which may properly be carried on in connection with the study of the evergreens.

In language it is obvious that any written or oral exercise describing the evergreens is simply one phase of English expression, and may very well be utilized as work in composition. It is also readily seen that the pupil who secures, through the study of the evergreens, adequate mental images of the characteristics of the different species, and of the appearance of the trees, either singly or in forest groups, is preparing himself to appreciate references to these trees in literature. This appreciation will be increased through the

use of selections from the best writers of prose and poetry, as recommended on a previous page.

The correlation with drawing is so evident that it need scarcely be dwelt upon. No nature study is at all adequate which does not constantly afford the child opportunity to express, through graphic representation, what he sees. In the case of the coniferous trees it is especially desirable that the appearance of the tree as a whole be represented from the




point of view of the art supervisor, and that the cover designs for the booklets be made according to his suggestions. It is desirable, also, that some of the selections be from those artists who have written appreciatively of the outer world.

It is easy to see the lines which should be followed in correlating the study of the evergreens with geography. The range maps will form the foundation for this. The use which is made of these trees for commercial purposes, as lumber, as the basis for wood pulp, as the source of turpen-

tine, pine tar, Canada balsam and similar products indicates that in treating of the product the source from which it comes should receive adequate consideration. The importance of the great coniferous forests as features of the landscape and as modifiers of climate are facts of great geographic interest. The natural distribution of our various native species may also serve as a basis for interesting studies in geography.

In the lower grades the bundles of needles of the pines could advantageously be used for combinations in number work. In the higher grades interesting computations may be made as to the number of leaves on a given branch or a given tree.

The value of the conifers in forestry and in ornamental planting will of course be emphasized. Wherever practicable each pupil should be led to transplant in spring or early autumn at least one evergreen about his home. Just as soon as possible there should be an assortment of native conifers growing on the school grounds.

## Sequence of Study.

A natural sequence of study of the evergreens through the grades may be indicated as follows: —

*Grades 1 to 3.* — Definite acquaintance, making through sense perceptions and name connections. The pupils to see, hear, feel, taste, plant and enjoy, in every way possible, as many of the evergreens as may be; and always to know the name of the species they are utilizing.

*Grade 4.* — Review of conifers in connection with topic of seed dispersal.

*Upper Grades.* — In one upper grade a definite study of the families of conifers, with individual booklets, including the native species. In other grades correlations with geography, language and drawing.

## Lists for the Lower Grades.

In making out the following list the species most easily recognized are placed first, although in many localities the sequence might well be modified to meet local conditions. The sequence is of comparatively little importance, however,

provided there is a definite list for each grade, so that when the pupils enter the fourth grade they will not have been studying a few of the abundant species to the exclusion of the others. Constant reviews, of course, are necessary, but when the pupils really know a species a new one should be taken up.

| *First Grade.* | *Second Grade.* | *Third Grade.* |
|---|---|---|
| 1. White pine. | 6. Red pine. | 11. Juniper. |
| 2. Pitch pine. | 7. Fir balsam. | 12. Red cedar. |
| 3. Norway spruce. | 8. Low juniper. | 13. Yew. |
| 4. Arbor vitæ. | 9. Black spruce. | 14. Red spruce; white spruce. |
| 5. Hemlock. | 10. American larch.[1] | 15. Cypress. |
| | | 16. Southern white cedar. |

A good time to begin the study of the conifers in any of the grades is late in November, four or five weeks before the holiday vacation. The subject can be gone over pretty thoroughly before the term ends, and rapidly finished when the winter term begins. It may well be followed then by a study of the broad-leaved evergreens.

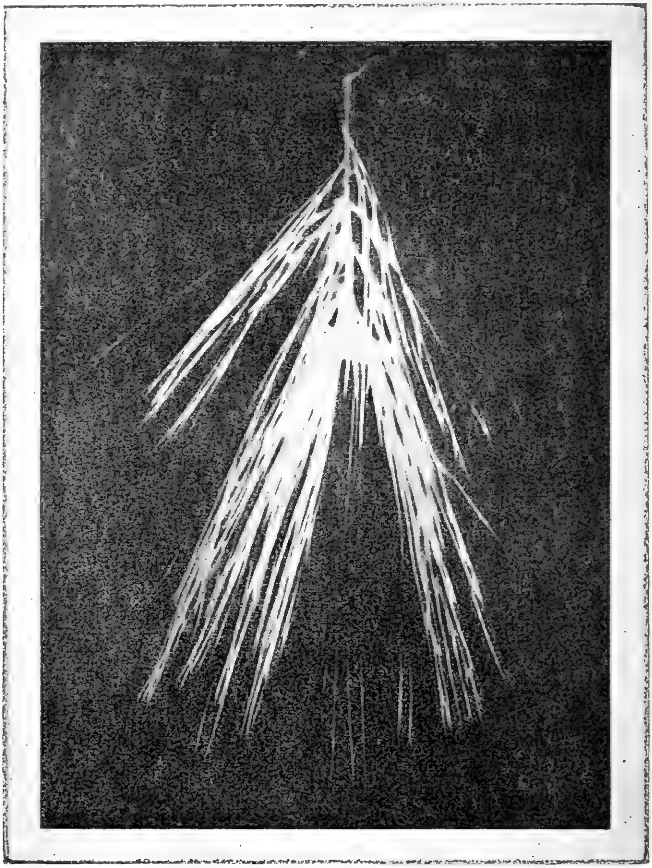
## The Conifers to Study.

### *First Year List.*

*White Pine* (*Pinus Strobus*). — Leaves arranged in clusters of five, each leaf being long and slender and averaging from 2½ to 4 inches in length; its margins are finely serrate, and in cross-section it is triangular. Green in color, with two or three distinct whitish lines on the two lower surfaces. Bark of young twigs olive brown, covered with a brownish pubescence; bark of older twigs smooth and shining. Scars where the bundles of leaves have fallen off broadly oval, sometimes nearly circular. Buds conical, with a distinctly pointed tip; they are rather small, averaging ¼ inch in length. Cones large, slender, 4 ~~feet~~ inches to 6 ~~feet~~ inches long; scales resinous, whitish brown, each scale distinctly pointed; rather

[1] While the larch is not an evergreen it is a conifer and is usually associated with evergreens.

thin at the tip, with their apical margins rounded and smooth. Seed with wing .9 inches long, light brown in color. One of our most important commercial trees, which is being planted in great numbers in Massachusetts for lumber purposes.



WHITE PINE.

*Pitch Pine* (*Pinus rigida*). — Leaves arranged in clusters of three, each leaf being long, rather stout and roughened by a row of serrations along three of the margins, the teeth pointing toward the tip. Green, with narrow rows of white spots on all the sides. Bark of young shoots yellow brown, not pubescent; its general appearance rough on account of

the scales, from in front of which the bundles of leaves come out. Bark of older branches duller yellow brown. Terminal buds very resinous, rather long, cylindrical with a conical tip, averaging 3/8 inch in length; usually two or three or more smaller accessory buds beside the main terminal bud. Cones large, broad, 2 ~~feet~~ inches long. Scales thickened at the tip, with a stout sharp spine at the middle of the outer margin; borne on the sides of the branches, often in small clusters. Seed with wing .6 inches long; wings very delicate in texture, whitish, with stripes of brown. Called also torch pine.

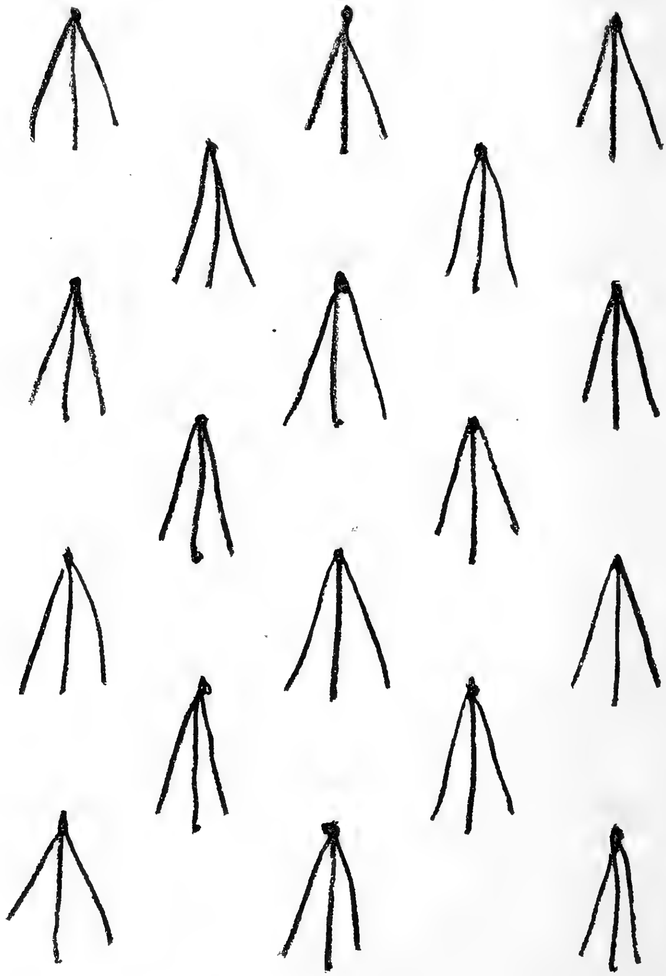
The pitch pine is a much less important tree than the white pine, but throughout the northern States it is abundant and generally distributed. The tree is at once distinguished from the white pine by the lighter color of its leaves, as well as by their coarser appearance, and by the broad cones which hang upon the branches in all parts of the tree for many years after the seeds have been dropped. The younger cones are bright reddish brown in color, while those which have been weather-beaten for many years become a dark slaty gray color.

*Norway Spruce* (*Picea excelsa*). — Bark of season's shoots light reddish brown; of older shoots much darker. Buds subconical, the imbricated scales reddish brown, with their margins slightly darker. Leaves yellow green, more bluish green on the under surface; arranged spirally on the branches, but the lower ones twisted around so as to give a flattened effect to the lower surface and a brushlike effect to the upper; average length, 1/2 inch. Cross-section of each leaf nearly square, with parallel rows of whitish dots upon each of the four sides; apex bluntly pointed. Cones very large, averaging when expanded 5 inches long by 2 inches broad. Margins of the scales rather thin, slightly and irregularly toothed, with the exposed portion having somewhat of a triangular effect, though the point of the triangle is generally truncate. Winged seeds light reddish brown in color, 1/3 inch long by 1/6 inch broad.

The Norway spruce is, perhaps, the most generally planted for ornamental purposes of all the evergreens. Although not a native species it is so universally distributed and its

cones are so characteristic that it probably will need to be included in any study of the evergreens.

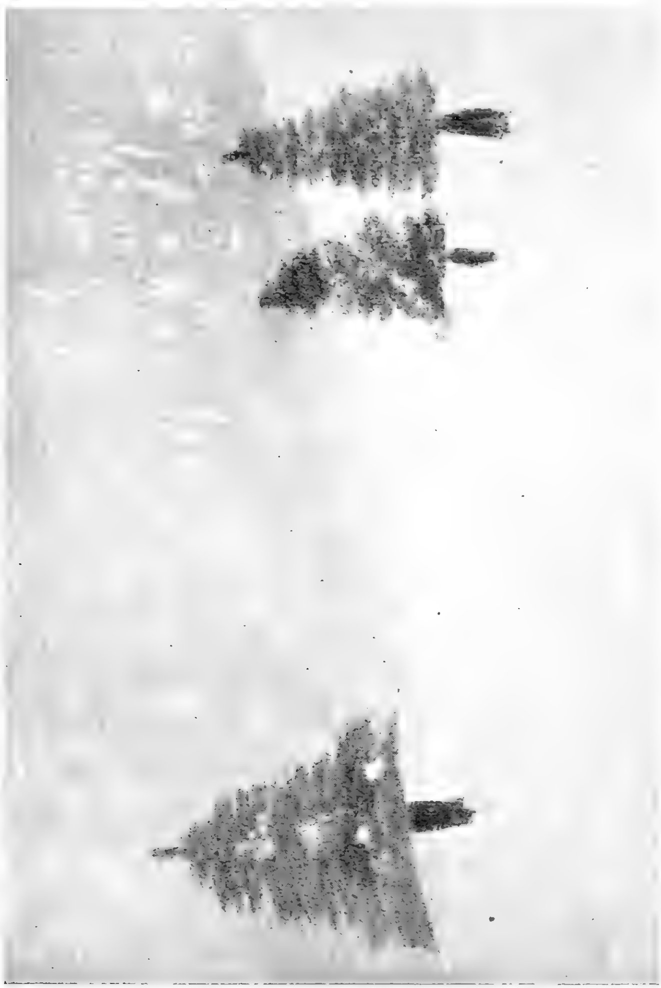
*Arbor Vitæ* (*Thuja occidentalis*). — Easily recognized among all the evergreens by the flattened, frond-like character



Design of Pitch Pine Needles. First Grade.

of the foliage, the leaves being very small and suggestive of closely appressed, imbricated scales. Bark of older parts of the twigs somewhat shining, grayish brown. Cones small, ovoid, .5 inches long, with few obtuse scales, chestnut brown

in color. Seeds elongate oval, broadly winged on both sides. Fully developed tree generally of conical form. Foliage with a distinct, characteristic, aromatic odor, which probably arises chiefly in the little glands upon the leaves.



Crayon Drawings of Pine Trees. First Grade.

The arbor vitæ is one of the most generally distributed of the evergreens. It is a native of the northern States, and is probably more widely planted for hedges in private grounds and public parks than any other conifer. The Indians used to call the plant by the characteristic name of featherleaf.

Some confusion is likely to arise because in many regions this species is called the white cedar, but it is very distinct from the true white cedar, or, as the latter is sometimes called, the southern white cedar. When growing in the open the arbor vitæ assumes the form of an attractive pyramidal tree.

*Hemlock* (*Tsuga Canadensis*). — Branches generally horizontal and having a flattened appearance, due in part to the horizontal position of the leaves, which are commonly two ranked on each side. There is also a row of leaves along the upper side of the twig, each leaf parallel with the twig, and in typical cases lying nearly flat upon it. In these cases the apex of the leaf points to the apex of the twig, so that the normal lower surface of the leaf becomes here the upper surface; these leaves are generally less than half the length of those that project sideways. The ordinary leaves generally a little less than ½ inch long and not quite $\frac{1}{12}$ inch wide, each leaf having a short petiole and generally a rounded tip; the upper surface bright, shining green, the under surface appearing very much lighter, due largely to the whitish stripes along the midrib and along each side of it. Crushed leaves have a distinctly resinous odor. Youngest twigs pubescent, light grayish brown in color; older twigs much darker and roughened by the scales from which the leaves have fallen. The leaves fall off in drying.

The hemlock is one of the best known and most characteristic of the evergreens. It is widely distributed throughout the United States and Canada, sometimes becoming a forest tree more than 100 feet high. The lower branches are apt to be scraggly, so that it is not so commonly planted in open ground as some of the other evergreens.

### *Second Year List.*

*Red Pine* (*Pinus resinosa*). — The red pine is at once distinguished from the other native pines of the northern States by its long leaves, arranged in pairs in a rather long sheath, and its cones, borne at or near the ends of the branches. The slender leaves are 4 to 6 inches long, and the sheaths are from ½ inch to 1 inch in length. The cones are only about 2 inches long, nearly egg shaped, and the scales are smooth.

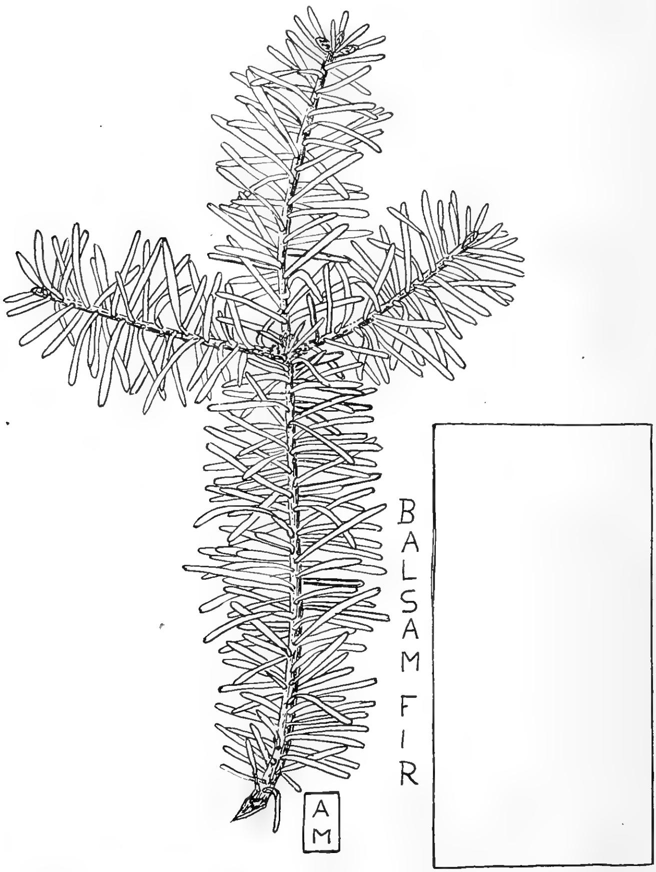
*Balsam Fir* (*Abies balsamea*). — General aspect of leafy horizontal branches flattened, due to the approximately horizontal position of the leaves. Upper surface a bright, clear green, under surface markedly bluish green. Each leaf sessile, averaging $\frac{3}{4}$ inch in length, with the sides nearly parallel and the apex distinctly notched; upper surface bright, deep green, with a longitudinal depression in the middle; lower surface with two broad whitish stripes, one on each side of the distinctly projecting midrib. Bark of season's shoots light reddish brown, rather thickly covered with stiff brown hairs; bark of older twigs darker. Buds clear reddish brown, with the imbricated scales covered by a transparent shiny varnish; subconical and rather small, averaging about $\frac{1}{6}$ inch. Leaves with a distinct balsamic odor and aromatic taste. Cones large, averaging 4 inches long by 1 inch wide, with the margins of the scales rounded; projecting upward from the small branches.

The balsam fir is an abundant tree in the northern forests. It is noted for the fragrance of its branches and for the transparent resin produced upon the bark, which is the source of the Canada balsam, largely used for preserving objects for microscopic study as well as for other purposes. The wood is used largely commercially in making paper pulp.

*Low Juniper* (*Juniperus nana*). — A low-growing shrub, often occupying circular areas in dry pastures and on open hillsides throughout the northern States and much of Canada. Leaves awl shaped, commonly coming out of the stem in whorls of three, sometimes simply opposite in two; hollowed on under side and curved downward as seen from above. Upper surface deep green; general effect of under surface blue green on account of the whitish stripes along the middle of the under surface of each leaf. Bark of the last season's twigs very light brown, with a greenish or grayish tint; bark of the next to the last season's growth reddish brown, and of older branches dark brown. Leaves .5 inches to .6 inches long. Fruit a berry-like object, $\frac{1}{4}$ inch long by $\frac{1}{5}$ inch broad; blue, with a glaucous bloom. The berry is formed by the union of the thickened fleshy scales, the tips of which may generally be seen. These enclose the three

nutlike seeds, which are curiously margined and sweetish aromatic in taste. When crushed the fruits have a distinctive aromatic odor. Called also ground cedar and ground hemlock.

*Black Spruce* (*Picea mariana*). — Bark of young branches reddish brown with a short pubescence, the hairs being brown-




ish or whitish. Leaves encircling the young twig yellow green or green in color; average length .4 inches; cross-section obtusely four angled; longitudinal lines of whitish spots generally to be found on each of the four sides; apex acute. Twigs straight or slightly curved, and commonly coming out of the main trunk nearly horizontally. Buds commonly arranged in groups of three at the ends of the more vigorous

twigs. Scales reddish brown, lower ones with long points at the tip, upper ones with thin margins; general shape ovate. Bark of older branches commonly blackish, giving a generally dark appearance to the tree, which grows especially in peat bogs from the far north southward to Michigan and New Jersey. Cone 9 inches to $1\frac{1}{2}$ feet long, oval in outline, each scale having along the outer margin numerous irregular teeth; remaining on the twigs for several seasons.

The black spruce grows abundantly in the so-called spruce bogs of the northern States. It is not a very good tree for ornamental purposes, as even in its favorite localities it is commonly unsymmetrical. It is often brought into the market as a Christmas tree.

*American Larch* (*Larix laricina*). — In early winter the twigs are commonly bare, having dropped the leaves late in autumn. Bark of season's shoots light reddish brown, with more or less of a glaucous bloom. Buds on these shoots globose, dark reddish brown, shining, the imbricated scales having thin margins. On older twigs the bark is darker, commonly being slaty gray in color, and the buds are on the tips of very short branches.

The American larch or tamarack is one of the most abundant cone-bearing trees to be found in the swamps of the northern States. It is a distinctive tree that seems to require an abundance of moisture. In the summer its numerous fine leaves give it an attractive appearance, which is largely lost when the leaves drop off late in autumn.

### *Third Year List.*

*Common Juniper* (*Juniperus communis*). — Distinguished from the low juniper by its tree-like form, with slender and rather straight leaves. It is a northern species, which extends southward to Michigan and New Jersey. By many botanists it is considered the same as the low juniper.

*White Cedar* (*Chamæcyparis thyoides*). — Bark of smaller twigs reddish brown, somewhat shining, with the ends more or less greenish. Leaf buds rather small, without scales. Leaves minute, scale-like, opposite and four ranked, covering the twig; tips sharply pointed. Most of the leaves have a

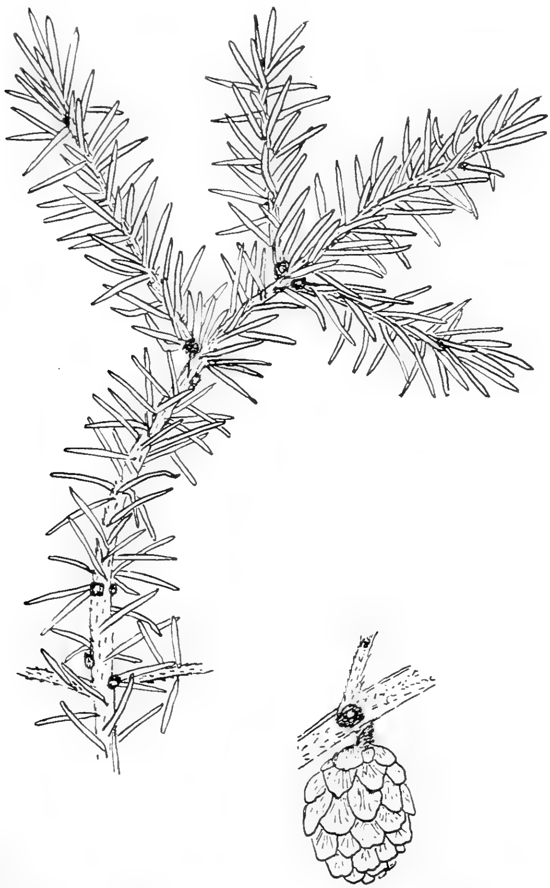
rounded greenish gland on the middle of the back. Fruit a curious cone, usually rather small, seldom more than ½ inch in diameter, with the scales opening on the inside and several minute winged seeds under each scale. Color of cone dull brownish purple. Called also cedar.

The white cedar is generally found along the eastern coast of the United States, although inland it occasionally occurs in deep swamps, where it often forms the principal tree growth. It is sometimes confused with the arbor vitæ, largely because the latter is also called white cedar. It is easily distinguished from the arbor vitæ by its curious brownish purple, more or less globular cones. The trees sometimes reach a height of 50 feet, and the wood is famous for its durable quality. Logs have been taken out of peat bogs and found to be in good condition to work into lumber.

*Red Spruce* (*Picea rubens*). — Leaves rather short, generally less than ½ inch long, obtusely pointed, dark green, with longitudinal rows of white dots showing through a lens. Surface of last season's twigs deep brownish red, with the distinct sterigmata which make up this surface covered quite densely with stout, prominent, brownish or blackish hairs, and with the projections that serve as the bases of the leaves unusually prominent. Bark of earlier years' growth darker, especially on the sides most exposed to the weather. Buds rather prominent, reddish brown or brownish red in color, darker at the obtusely pointed apex. Surface of buds hairy. Cones deep reddish brown in color, quite regular in size and shape, when fully opened averaging 1½ inches long by 1 inch wide. Scales with the margin slightly irregular, giving a suggestion of short, obscure teeth. Seed with its wing ⅓ inch long, the wing at its broadest part being half that width. General outline broadly triangular, with the light grayish brown wing terminal on the dark brown seed.

*White Spruce* (*Picea Canadensis*). — Bark of season's shoots light brown, with bases of leaves of a slightly reddish brown tinge; bark of older branches very much darker. Buds subconical; scales reddish brown, imbricated. Leaves bluish green, a little lighter when seen from below; those on the under part of the twig twisted around so as to give the upper

surface of the branch a much more dense appearance than the lower surface. Average length of the leaf $\frac{1}{5}$ inch; four angled, sharply pointed at tip, with stripes of white dots on each of the four sides. The bruised leaves have a pungent, aromatic, slightly disagreeable odor. Cones generally termi-



BLACK SPRUCE

nal on the smaller twigs, when fully developed averaging $1\frac{1}{2}$ inches long by $\frac{3}{4}$ inch broad, generally ovate cylindrical when opened. Scales with thin and more or less rounded margins, the middle of the margin being commonly truncate and generally entire. Seeds rather small; length with wing being but $\frac{1}{4}$ inch; width of wing $\frac{1}{6}$ inch.

The white spruce is one of the most beautiful of our native evergreens, forming a tall pyramidal tree, with the branches extending from the ground. The cones drop off soon after fruiting, so that they may be found beneath the tree at any time. The blossoms appear during April and May.

*Red Cedar* (*Juniperus Virginiana*). — The twigs of this common evergreen are especially interesting because of their two forms of leaves. In one form the leaves are small and scale-like, arranged in opposite pairs which alternate with each other, each leaf being acutely pointed and subtriangular in its shape. The other form of leaf is long and slenderly lanceolate or needle-shaped, with a very sharp point. This second form of leaf seems in general to be present upon the twigs and branches which have grown rapidly. The bark of the older parts of the branch is reddish brown and shining. The fruit is a bluish, berry-like object, the size of a pea, in which the thickened outer scales have grown together to enclose the three or four angular seeds. Called also savin.

The red cedar is an interesting and characteristic tree, scattered over almost the whole of eastern North America. It varies greatly, but in its typical form it has a characteristic columnar appearance which is very attractive. The berries form a large part of the winter food of many birds, so much so in the case of the cedar bird as to give that species its common name. The tree belongs to the genus *Juniperus* and is sometimes called the red juniper.

*American Yew or Ground Hemlock* (*Taxus baccata*). — General appearance of the leafy branches flattened in a way suggestive of the hemlock, the leaves, however, being much larger and more robust, and the color very much more of a yellow green. Average length of leaves ½ inch to ¾ inch; width, $\frac{1}{12}$ inch. Each leaf narrowed at the base into a short petiole and sharply pointed with a mucronate apex; longitudinally convex above and concave below. Midrib projecting on both surfaces, more prominent on upper. Shining yellow green on the upper surface, less shining and lighter on lower surface. Bark of young twigs shining greenish brown; of older twigs reddish brown. Buds small, with rather thick imbricated scales. Each scale brownish green, with a whitish longitudinal stripe along the middle and sometimes upon the

margins. Fruit a curious, red, berry-like object, formed by the disk becoming pulpy and cup-shaped, so as almost to cover the hard seed; 1/4 inch long. Small masses of the cut twigs have a curious musky odor, very different from that of any other of our evergreens. The leaves remain upon the twigs in drying.

## Synopsis of the Conifers.

The conifers as a whole are distinguished from the majority of seed-bearing plants in that the seeds are borne on the face of a scale rather than enclosed in an ovary. Our native species belong to two families, — the pine family, which includes all but one of them, and the yew family. The former is characterized by cone-like fruits, while the latter is characterized by its soft, berry-like fruit.

### *The Pine Family (Pinaceæ).*

*The Pines (Pinus).* — The pines are known by having the leaves needle-shaped and in clusters of two to five, and by the numerous woody cone scales. The three following species are the most generally distributed native species: —

*White Pine (Pinus Strobus).* — Leaves long, five in a sheath; cone long, with margins of cone scales smooth and unarmed.

*Pitch Pine (Pinus rigida).* — Leaves long, three in a sheath; cone broad, with outer end of cone scale armed with a pointed tooth.

*Red Pine (Pinus resinosa).* — Leaves long, two in a sheath; cones not long, oval conic; margins smooth.

### *The Larches (Larix).*

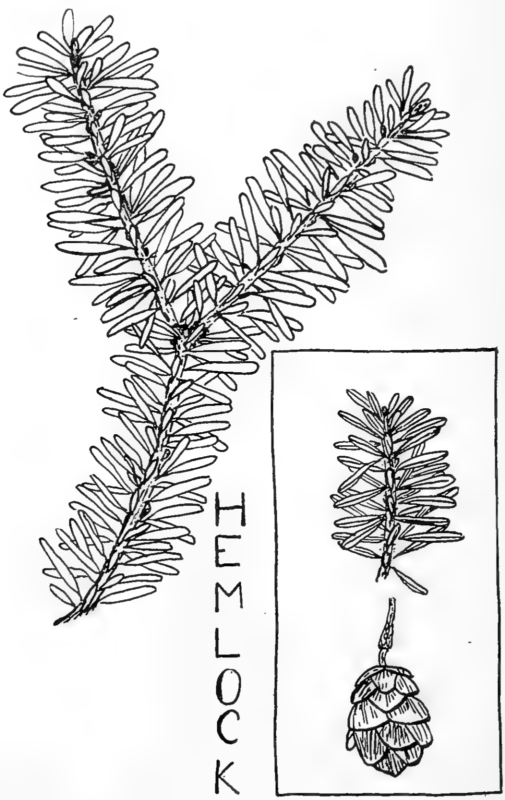
The larches are characterized by having the leaves in dense clusters on the ends of very short branches, the leaves falling off late in autumn. Our native species: —

*American Larch or Tamarack (Larix laricina).* — Small, short, pale green leaves, in dense clusters. Small branches, not drooping. Cones persistent and erect on twigs.

*European Larch (Larix Europæa).* — Distinguished by the drooping character of the branches. Commonly planted for ornament.

*The Spruces (Picea).*

In their general aspect the spruce trees are similar, being conical in outline and having rather short, four-sided leaves, which spread in all directions on the branches, although they




commonly project upward in a manner that gives them a brush-like effect. Leaf buds scaly and generally more or less resinous.

*Norway Spruce (Picea excelsa).* — Distinguished by the large cones, 4 or 5 inches long, and the drooping position of the smaller branches. An introduced species.

*White Spruce (Picea Canadensis).* — Distinguished by the absence of hairs upon the bark of the smaller branches; cones oblong, cylindrical.

*Red Spruce* (*Picea rubens*). — Distinguished by slender pubescent twigs, with sharply pointed leaves, and cones that fall off.

*Black Spruce* (*Picea mariana*). — Distinguished by stout pubescent twigs, with the leaves abruptly pointed, and cones that remain upon the tree.

*The Hemlock* (*Tsuga Canadensis*).

Only one species in the northern States, distinguished by flat leaves with short petioles.

*The Balsam Fir* (*Abies balsamea*).

Easily recognized by the erect cones and the rounded or notched tips of the rather large, flattened leaves.

*The Bald Cypress* (*Taxodium distichum*).

This tree has not before been mentioned in this article, as it is a southern species, ranging north to Delaware. The scales of the small cones are arranged spirally and the leaves are deciduous.

*The Arbor Vitæ* (*Thuja occidentalis*).

Easily recognized by the flattened appearance of the branches, and the small cones with opposite scales.

*The Southern White Cedar* (*Chamæcyparis thyoides*).

Known by the small, scaly leaves and the globose cones with peltate scales, each scale having a projecting tooth on the middle. Ranging as far north as Massachusetts.

*The Junipers* (*Juniperus*).

The junipers are readily known by their fleshy, berry-like fruits, which are cones modified through the thickening of the scales. The leaves vary much in size in the different species. Many leading botanists now separate the common juniper into two species, juniper and low juniper, according to its tree-like or spreading habit.

*Juniper* (*Juniperus communis*). — A tree-like shrub or

small tree, having awl-shaped leaves nearly ½ inch long, arranged in whorls of three. Fruit a berry-like cone, dark blue, with a glaucous bloom when ripe.

*Low Juniper* (*Juniperus nana*). — A low, spreading shrub, very abundant in rocky fields in many regions, with awl-shaped leaves arranged in whorls of three, and berry-like fruits; dark blue, with a glaucous bloom when ripe. Called also ground cedar.

*Red Cedar* (*Juniperus Virginiana*). — A tree or tree-like shrub with two kinds of leaves, partly small and scale-like and partly longer and awl-shaped. Fruit, berry-like, similar to that of the low juniper, borne on short, straight twigs.

*Shrubby Red Cedar* (*Juniperus Sabina*). — A shrubby procumbent form, similar to the red cedar except that the fruit is on recurved twigs. Found in northern regions, extending southward only to Maine, northern New York, Minnesota and Montana.

### *The Yew Family* (*Taxaceæ*).

*The Yew* (*Taxus Canadensis*). — Characterized by the red, pulpy, resinous fruit partially enclosing the seed, and the linear leaves with short petioles and awl-shaped tips. A low shrub.